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Combat Vehicle Command and Control Systems: III. Simulation-Based Company Evaluation of the Soldier-Machine Interface (SMI)

Frances M. Ainslie, Bruce C. Leibrecht, and
Nancy K. Atwood
BDM International, Inc.

December 1991

United States Army Research Institute
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To improve the command and control of armor units, the Army is conducting research and development on automated command, control, and communication for future tanks: the Combat Vehicle Command and Control (CVCC) system. This research investigates the extent to which the CVCC soldier-machine interface (SMI) supports the soldier's ability to learn and effectively operate the system. For the research, 105 U.S. Army personnel participated in 5 weeks of training and testing. Automated measures of equipment use and subjective assessments indicate that, overall, the CVCC is a useful and usable system that participants feel will improve their performance. Problems with usability were noted for select functions. Recommendations for improvement focus on providing alternative input methods, enhancing the digital report function, and improving feedback to vehicle commanders and drivers.

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FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) Future Battlefield Conditions Team at Fort Knox conducts research to address critical aspects of command, control, and communication (C^3): soldier performance, soldier-machine interface (SMI), and simulation. A key objective of the task, entitled "Training Requirements for the Future Integrated Battlefield," is to provide research-based recommendations for presentation of information to operators and to provide methods to use soldier-in-the-loop simulation to prove the value of automated C^3 to the maneuver forces. Work conducted under this program is supported by Memoranda of Understanding (MOUs) between ARI-KNOX and the U.S. Army Armor Center (USAARMS) dated 12 April 1989 and ARI-KNOX and the U.S. Army Tank-Automotive Command (TACOM) dated 22 March 1989. The research was conducted using the Close Combat Test Bed (CCTB) at Fort Knox. The CCTB uses selective fidelity networked simulation to represent battlefield environments for soldier performance research.

This report presents findings and recommendations on the SMI of an automated C^3 system: the Combat Vehicle Command and Control (CVCC) system. The CVCC is an experimental configuration that supports the requirements of AirLand Battle by increasing the ability of lower-echelon commanders to synchronize, plan, and control combined arms operations throughout their respective areas of influence. CVCC capabilities include a Commander's Independent Thermal Viewer (CITV), a real-time tactical map display, position navigation (POSNAV), and the ability to electronically prepare, transmit, and receive reports, battlefield intelligence, and orders. This report provides information to developers of automated C^3 systems and to evaluators testing those systems.

Results of this effort have been briefed to the USAARMS Directorate of Combat Developments (DCD) and the Director, Vetronics Division, TACOM Research, Development and Engineering Center.

EDGAR M. JOHNSON
Technical Director

ACKNOWLEDGMENTS

The company-level CVCC evaluation was a major undertaking requiring a concerted and coordinated effort by a large number of individuals. Technical guidance was provided by Dr. Barbara Black, team leader of the Future Battlefield Conditions (FBC) Team at the U.S. Army Research Institute for the Behavioral and Social Sciences Fort Knox Field Unit. Other members of the FBC Team, Dr. Kathleen Quinkert and Dr. Carl Lickteig, also provided extensive input, particularly in the training and soldier-machine interface (SMI) areas. Major Milton Koger, the ARI Field Unit Research and Development Coordinator, provided substantial administrative support in coordinating requirements for soldier participants.

The BDM International, Inc., on-site contract support team implemented all phases of the evaluation. The team was headed by Dr. Bruce Leibrecht, senior research scientist. Other members of the on-site team included Mr. James Kerins, command and control subject matter expert; Ms. Frances Ainslie, research scientist; Ms. Mary Campbell, junior research scientist; Ms. Karen Lameier, junior research scientist; and Ms. Alicia Sawyer, junior research scientist. Off-site personnel supporting this effort included Dr. William Doherty, program manager; Dr. Nancy Atwood, project director; and Dr. Jerry Childs, project director.

The evaluation resulted in a large, multifaceted set of data. To facilitate presentation of findings, four reports have been developed, each report focusing on a different aspect of the data. Since the data all derived from a single evaluation effort, they share the same background and methodology. Consequently, the authors of all four reports have relied on common narrative where appropriate. This approach ensures clarity and consistency across the separate reports. The occasional use of uniform text is limited to the introduction, design, and method sections of the reports. The commonalities reflect the full knowledge and agreement of all authors.

COMBAT VEHICLE COMMAND AND CONTROL SYSTEMS: III. SIMULATION-BASED COMPANY EVALUATION OF THE SOLDIER-MACHINE INTERFACE (SMI)

EXECUTIVE SUMMARY

Requirement:

To improve the command and control of armor units, the Army is conducting research and development on automated command, control, and communication for future tanks: the Combat Vehicle Command and Control (CVCC) system. The capabilities of the CVCC configuration include a Commander's Independent Thermal Viewer (CITV), a real-time tactical map display, position navigation (POSNAV), and the ability to digitally prepare, transmit, and receive reports, battlefield intelligence, and orders. To provide empirical data regarding the usability of the soldier-machine interface (SMI), this research incorporated a user-based evaluation to investigate the extent to which the CVCC SMI supported the soldier's ability to learn and effectively operate the system. This research, part of a larger company-level evaluation of soldier performance, was conducted using the Close Combat Test Bed (CCTB) at Fort Knox.

Procedure:

One hundred and five (105) U.S. Army personnel--20 commissioned officers, 15 noncommissioned officers, and 70 enlisted men--participated in 5 weeks of data collection. During each 5-day training and testing period, seven manned simulators (with autoloaders) and six semiautomated vehicles formed a "company." Tank crews were comprised of a vehicle commander, gunner, and driver. Each company received 2½ days of training and then completed two simulated combat test scenarios. During test scenarios, equipment usage was recorded by an automated data collection and analysis system. After the second test scenario, participants responded to equipment evaluation questionnaires that addressed usability, usefulness, and suggestions for improvement.

Findings:

Overall, vehicle commanders found the CVCC configuration, particularly the Tactical Map, easy to use and understand and felt that it would improve their ability to command tanks. However, problems with the automated report function were identified. Vehicle commanders indicated that they received too

many reports; automated usage data disclosed that redundant report actions (sending and relaying) on the part of vehicle commanders were contributing to the overload. Evidence suggested these redundant actions were the result of inadequate feedback. Additionally, preformatted reports were felt to be lengthy and nonstandard (as were report icons).

Gunners and drivers also rated the equipment favorably and felt it would improve their performance. Problems with crew coordination for target hand-off were identified by gunners. Drivers indicated a need for auditory signals upon arrival at destination points (waypoints) and a cardinal direction indicator.

The aggregate findings led to a number of recommendations for improvement. These recommendations focused largely on providing alternative methods of input, enhancing the digital report function, and improving feedback for vehicle commanders and drivers. Additional recommendations included adding cardinal direction to the driver's steer-to-indicator.

Utilization of Findings:

The results of this evaluation provide input to the design and evaluation of automated command and control systems being developed for combat vehicles. They also provide training developers, combat developers, independent evaluators, and future researchers with useful information regarding the use and evaluation of automated command and control systems.

COMBAT VEHICLE COMMAND AND CONTROL SYSTEMS: III. SIMULATION-BASED COMPANY EVALUATION OF THE SOLDIER-MACHINE INTERFACE (SMI)

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COMBAT VEHICLE COMMAND AND CONTROL SYSTEMS: III. SIMULATION-BASED COMPANY EVALUATION OF THE SOLDIER-MACHINE INTERFACE (SMI)

Introduction

Advances in automated command, control, and communication (C^3) systems are resulting in increasingly sophisticated battlefield equipment. New technologies based on microprocessors, reconfigurable software, and digital burst communications are contributing to future battlefield systems that will call upon commanders and soldiers to operate complex suites of C^3 equipment. These advances focus attention within the armor research and development community on soldier-in-the-loop requirements. The advantage to be gained over the adversary in virtually every future engagement lies not in equipment and technology, per se, but in the optimized use of that technology by soldiers.

The research on which this report is based--the Combat Vehicle Command and Control (CVCC) company evaluation--was designed to systematically evaluate soldier performance issues associated with an armor-based experimental C^3 configuration known as CVCC. Additionally, the purpose of the research was to demonstrate the concept of automated C^3 in ground combat vehicles and to identify critical training and soldier-machine-interface (SMI) issues associated with the use of automated C^3 tools. The results of this research provide information to developers of automated C^3 systems and to evaluators testing those systems.

This report focuses on the evaluation of the CVCC SMI and is one in a series of four reports that document the CVCC company evaluation. It is organized into five major sections as follows (Appendix F provides a list of all acronyms used in this report):

Introduction - outlines the principal SMI research objective and associated research issues and provides a brief overview of the CVCC evaluation and the test facility.

Background - presents a review of key literature that characterizes past research and development efforts relevant to the SMI evaluation.

Method - defines the CVCC system, study participants, test materials and procedures, and data analysis.

Results and Discussion - describes and interprets the findings related to equipment usage patterns, questionnaire results, and participant comments in the context of the SMI research issues.

Summary and Recommendations - summarizes key findings and sets forth data-based guidance and recommendations for system design.

As applied to computer systems, SMI refers to aspects that are directly involved in interactions between the computer system and users of the system (in this case, soldiers). It includes input devices, menus, and the way information is presented on the screen (see Figure 1). The interface is the surface through which information flows and is related to what users see, have to know to interpret what they see, and can or must do to gain useful results (Whiteside, Bennett, and Holtzblatt, 1988). The design of the interface influences the soldier's ability to operate the system and to gain useful results. The SMI evaluation sought to determine the extent to which the CVCC interface supported the soldier's ability to do so.

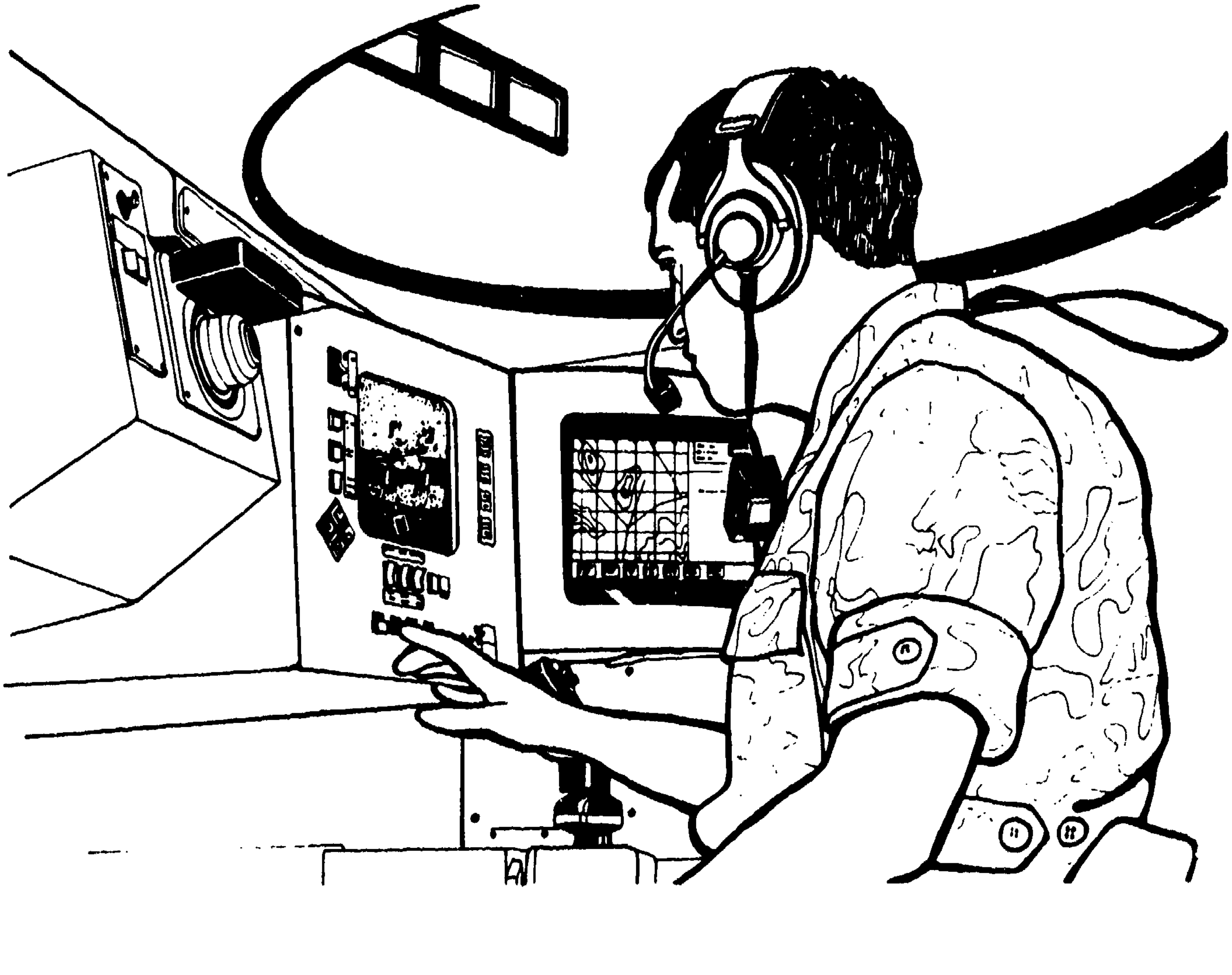

Figure 1. The CVCC vehicle commander's workstation, illustrating the soldier-machine-interface.

Overview of CVCC Company Evaluation

The CVCC company evaluation, of which the SMI evaluation is a part, is the latest in a series of simulation-based evaluations conducted by the Army Research Institute (ARI) Fort Knox Future Battlefield Conditions (FBC) Team. The FBC Team heads a program of research to address critical aspects of C^3: Soldier Performance, Soldier-Machine-Interface (SMI) and Simulation. A key objective of the Team is to provide research-based recommendations for the presentation of information to operators and to utilize soldier-in-the-loop simulation to prove the value of automated C^3 to the maneuver forces.

Based on the primary questions of interest, planning and implementation of the CVCC company evaluation incorporated three overall objectives:

(1) Evaluate the operational effectiveness of armor companies using CVCC.

(2) Identify critical SMI issues associated with the use of CVCC and make recommendations concerning system design.

(3) Determine operational training requirements, issues, and concerns for CVCC.

Objectives one and three are addressed in separate reports. The reader is referred to the primary report (Leibrecht, Kerins, Ainslie, Sawyer, Childs, and Doherty, in preparation) for in-depth coverage of the CVCC company evaluation and research objective one. Research objective three is addressed in a companion report by Atwood, Quinkert, Campbell, Lameier, Leibrecht, and Doherty (in publication). Further analysis of the CVCC company evaluation is provided in Kerins and Leibrecht (in preparation).

SMI Evaluation Research Issues

This SMI evaluation addresses the second CVCC company evaluation objective. In order to identify critical SMI issues it was necessary to define the qualities of a "good" system and to then determine if the CVCC possessed those qualities. However, even though users and designers can identify any number of qualities which good systems should possess, no single definition of a good system exists. For the purposes of this evaluation we have used Gould's (1988) definition of a good system as one which is usable--can be operated successfully without undue effort or error; useful--enables users to do the things they need or want to do; and is well liked. These qualities defined evaluation issues so that problematic features of the CVCC could be identified and recommendations for their improvement could be developed. In addition to investigating these qualities, differences in equipment usage based on vehicle commander duty position (Company Commanders vs. Platoon Leaders vs. Platoon Sergeant/Wingmen) were assessed. Differences based on duty position might result from the amount of command and control activities in which vehicle commanders engage and the duties incumbent upon each duty position. This information is of use to system developers and combat developers. Further information concerning the CVCC SMI was sought from gunners' and drivers' perceptions of the CVCC, and from participants' suggestions for improvement.

The research issues which address the current SMI research objective are as follows:

(1) Is the CVCC usable--can it be operated with a minimum of effort and error? For example, which input method do vehicle commanders use most often and which method do they believe makes it easier to operate the CVCC? Do these differ according to duty position?

(2) Is the CVCC useful--does it enable vehicle commanders to perform their assigned duties? For example, are they able to use the tactical map as they use a paper map and do they believe the CVCC would improve their "real world" performance as a commander. Do these differ according to duty position?

Information from SMI evaluations is essential to system designers and is an important link in the system development process. During the development process, design decisions are continually being made. However, the complexity of the interface makes it difficult to know the consequences of these decisions. Even the most insightful designers cannot take the place of the intended user. User-based evaluations provide critical information in determining the consequences of design decisions and their impact on usability. Further, understanding the user's experience with a system leads to improvement of that system. An iterative approach to the design of the SMI, which takes the information from user-based evaluations back to designers for implementation and then further evaluation, provides a strong foundation for a usable system. This iterative design approach has been used by the FBC Team in the development of the CVCC.

The FBC Team has pioneered and sustained the application of simulation to evaluate emerging C^3 concepts related to armor system design and development. Applied behavioral research conducted and monitored by the FBC Team over the past three years has focused on CVCC components and their ability to improve armor crew and platoon performance. These component systems were: an automated Position Navigation (POSNAV) system (Du Bois and Smith, 1989); the Commander's Independent Thermal Viewer (CITV), a surveillance and target acquisition system (Quinkert, 1988 and 1990; Fisicaro, 1989); and the Intervehicular Information System (IVIS), an automated C^3 configuration (Du Bois and Smith, 1990). While the major emphasis of this research has been the tactical performance of crews and platoons using these components, SMI and training requirements issues have been addressed as well. Each of the three components (POSNAV, IVIS, and CITV) has been evaluated independently of the others. To date, no research has been undertaken to evaluate operational performance enhancements, SMI issues, and training requirements associated with the integration of the three conceptual systems, and at the company level. The CVCC Company Evaluation was conducted to fulfill these requirements. Future evaluations will focus on operational performance, SMI issues, and training requirements associated with the CVCC at the battalion level.

Overview of the Close Combat Test Bed

One of the foremost tools for conducting low-cost armor C^3 combat simulations has been the Close Combat Test Bed[1] (CCTB) employing selective fidelity networked simulation at Fort Knox, Kentucky. As human performance research initiatives have evolved in conjunction with evaluations of new technology, the test bed has been used increasingly as a soldier-in-the-loop research facility. The CCTB represents a pioneering armor C^3 simulation research and development program. It is designed to realize low-cost, unit-level, full mission simulation using extended local and long haul networking and families of simulators supported by site-specific microprocessors (Miller and Chung, 1987; Du Bois and Smith, 1989). A primary feature of the architecture is the employment of selective physical and functional fidelity to achieve desired levels of the C^3 system realism. Selective fidelity enables the system's performance to be sufficiently emulated to elicit the required levels of perceptual realism among users (Chung, Dickens, O'Toole, and Chiang, 1988). The CCTB, for example, allows the Army to simulate and assess combat capability using experimental C^3 configurations prior to final design production and field implementation, as the FBC Team has used it in the CVCC research program.

The next section provides an overview of SMI findings from previous evaluations of CVCC components.

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[1] The CCTB was formerly referred to as the Simulation Network - Developmental Facility, or SIMNET-D. For clarity and continuity the term CCTB will be used throughout this document to refer to the facility. However, SIMNET will be used when referring to the technology of distributed network simulation.

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Background

A major thrust of the FBC Team has been to systematically investigate issues related to SMI design. These evaluations have been aimed at deriving empirical evidence for improving the SMI of CVCC components and their findings have been incorporated in the iterative design of the CVCC. Iterative design provides for early and continual focus on users. It is the means by which informed user-based input is derived and fed back to developers for implementation and then further evaluation.

During the design process the developers, researchers, and software/hardware engineers make a series of decisions which are based on required operating characteristics and which successively drive the design of the interface. However, the design team does not have at its disposal all the answers to design questions and is often forced to make design trade-offs, the implications of which cannot be intuited. There are errors, misconceptions, and novel uses which can only be discovered through user testing. Thus, an iterative approach to system development and interface evaluation can provide a means of deriving valuable information related to design decisions (Virzi, 1989). This iterative, user-based evaluation approach takes the interface beyond the realm of taste and preference of design teams in order to design a system which has the functions which allow users to not only do their job but to do it better.

Previous evaluations in the CVCC design process have included SMI issues related to individual system components operating at the crew and platoon level. As such, they provide the foundation for the SMI evaluation of the integrated CVCC at the company level reported here. Figure 2 graphically depicts these investigations and their SMI findings. As represented in this figure, findings from previous evaluations have provided the basis for subsequent design decisions. Likewise, the results of the company evaluation will provide user-based design information with which to further refine the CVCC SMI. The terminal box in Figure 2, labelled "CVCC Company SMI Evaluation", contains the components of the CVCC system. What was previously referred to as IVIS has become part of the Command and Control Display (CCD), which includes POSNAV information displayed on a Tactical Map, and the communications element of the CVCC (CVCC components are described in detail in the next section). Design changes forthcoming from the company evaluation will be evaluated during the upcoming CVCC battalion evaluation of 1992. It is this cycle of design-evaluate-design which will result in a CVCC design responsive to the needs, strengths and limitations of its users. The following paragraphs discuss the evaluations represented in Figure 2.

Lickteig (1986) investigated user interface requirements for the Battlefield Management System (BMS), an early counterpart to the CVCC. At that time, BMS was conceptualized as an integrated complex of battlefield information acquisition, processing and communication technologies aimed at enhancing command and control

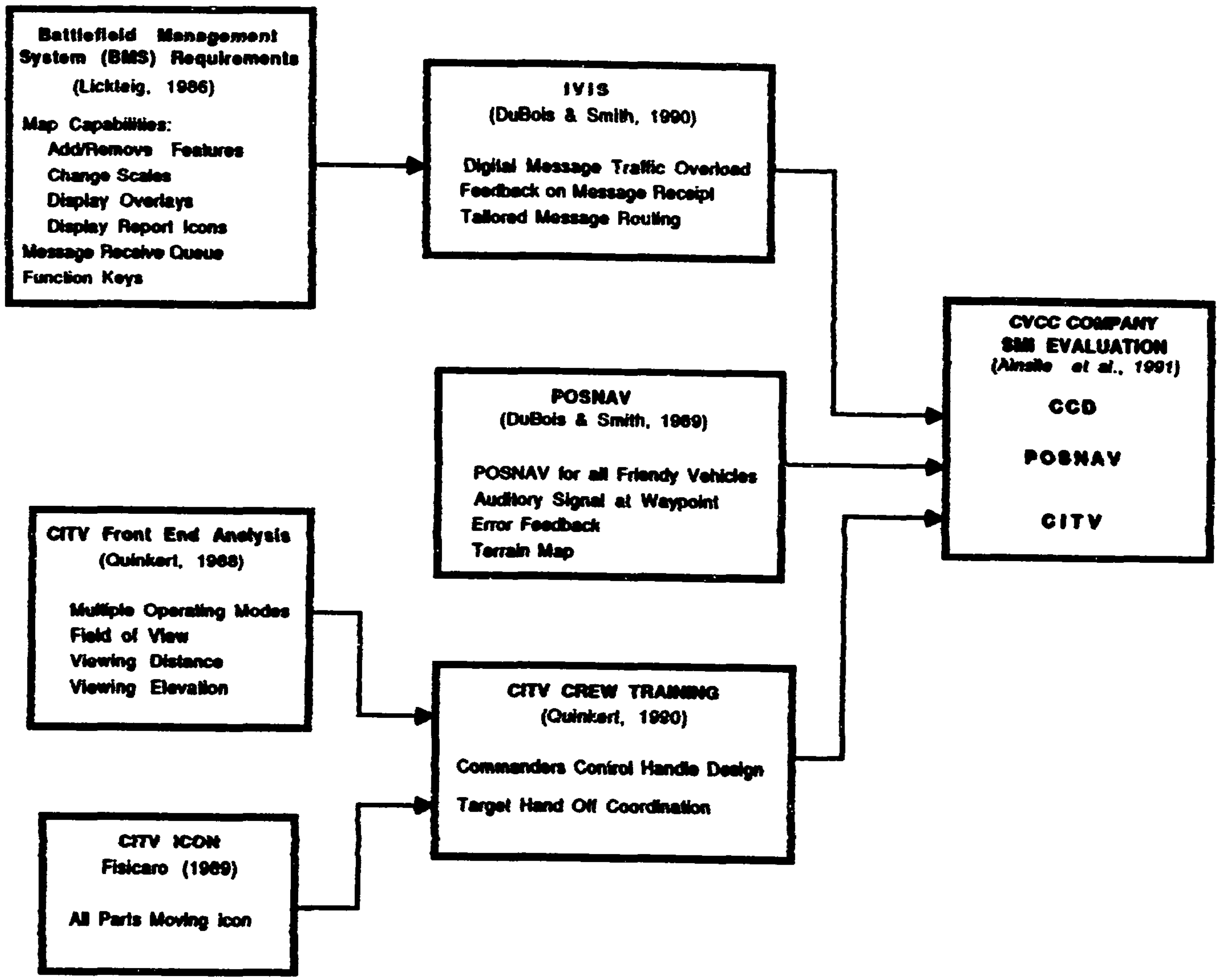

Figure 2. CVCC iterative design and evaluation: Previous SMI findings.

by the small unit leader. To examine user requirements for the system, a prototype interface was developed on an Integrated Raster Imaging System 1400 computer system. Small unit leaders worked with a digitized terrain database and used menu-structured report functions to construct map displays and tactical reports needed for their respective duty positions. Data on requirements for display features, control functions, size, and operating characteristics of the BMS interface were gathered in structured interviews, while participants worked with the BMS.

Findings indicated that a map display, as comparable as possible to a conventional military map, was a particularly salient interface requirement for users. Since it was anticipated that the size of the map display would be relatively small (7 X 9 inches), users underscored the need for map features and functions that would allow them to tailor the map to their immediate task requirements. These included the capabilities to: 1) select and delete man-made and natural terrain features and operational overlays; 2) resolve the map display to the user's immediate area of interest by adjusting the map scale; and 3) display redundant pictures and symbols to represent control measures and overlays. Users viewed structured menus and pre-formatted entry forms (as opposed to free text keyboard entry) as easy to use and a promising approach for C^3 functions. They did however note the need to streamline reporting functions to keep workload manageable. Perhaps even more importantly, they suggested the need for integrating map and report functions so that spatial map and graphics data could be integrated with verbal reports and orders.

Results also suggested that dedicated function keys (e.g., for specific types of reports), a permanent window for incoming alerts and signals, a date and time window, and functions to facilitate digital communications such as function keys for radio frequency and channel designation were viewed as desirable by users. Finally, underscored was the fact that automated C^3 devices such as CVCC may require significant changes in the standard operating procedures (SOPs) of users. This observation highlighted the need for examining equipment design in concert with user SOPs to identify needs for improvement on both sides. Lickteig's findings were incorporated in the IVIS and the CCD, although function keys related to radio communication were not.

Quinkert (1988) conducted a front-end analysis of the design and functional requirements for the CITV, a key component of the CVCC system. This analysis was based on a review of research and development documents, initial design concepts and hardware proposals, technical manuals for the tank vehicles that would house the CITV, and findings from the ARI research program.

The underlying concept for the CITV was that it would serve as an integral component of the CVCC by providing an independent laser capability to serve as the "eyes" of the management system. The CITV is intended to serve as a real time thermal viewer which increases the vehicle commander's field of regard during conditions of darkness, heavy concentrations of artillery, and other decreased visibility or closed-hatch conditions. It can be used in either a closed or open hatch mode for surveillance and target acquisition. Additionally, the CITV provides a "Hunter-Killer" capability for the tank commander and the gunner in which the commander conducts an independent target search and hands targets off to the gunner.

Three operational modes were identified as necessary to implement the "Hunter-Killer" concept. The first would allow the commander to independently survey the battlefield in either an automatic scan or a manual search mode. The second would slave the CITV to the gunner's primary sight to allow the commander to monitor or check the priority of a target. The third would slave the turret/main gun to the CITV line of sight to facilitate target engagements.

Quinkert (1988) examined issues related to the design of the CITV, particularly from the vantage point of the vehicle commander. Issues of importance included design of the display and controls in general and for target hand off in particular. Specific issues included the need for realistic image presentation (especially field of view, elevation, viewing distances and resolution levels), switch/handle configurations and work space constraints. Quinkert's findings were incorporated in subsequent CITV configurations.

Subsequently, Quinkert (1990) examined soldier performance, training requirements, and SMI issues associated with the CITV using Unit Conduct of Fire (UCOFT) simulators with and without a CITV. Vehicle commander-gunner pairs were tested on the same scenarios and target acquisition was measured in speed, accuracy, and number. Subjective assessments of the SMI, workload, and training issues were collected. While the CITV group detected and killed more targets more quickly, Quinkert identified training issues associated with coordination problems between vehicle commanders and gunners and recommended SMI improvements to the commander's control handle.

In a related effort, Fisicaro (1989) evaluated one specific aspect of the CITV interface: the orientation icon, which represents the vehicle commander's own tank and is displayed in the lower center of the CITV. Four different icons were investigated. All four contained three parts: Hull, CITV Line of Sight (LOS) and Main Gun. They differed based on whether a given part was stationary or moving: 1) hull stationary with moving CITV LOS and main gun; 2) main Gun stationary with moving hull and CITV LOS; 3) CITV stationary with moving hull and main gun; and 4) all parts moving.

Tank crewmen were tested as tank commanders with a Unit Conduct of Fire (UCOFT) simulator equipped with a prototype CITV. The research used three major sources of data including actual performance measures (e.g., orientation errors), confidence ratings from soldiers, and evaluations and recommendations from soldiers. Analyses of performance measures and confidence ratings made by the tankers favored the all parts moving and the hull stationary icons. A preference measure also indicated that soldiers preferred these. Although no clear preference for one over the other emerged, the all parts moving icon was selected for integration into subsequent CITV configurations, including CVCC.

Du Bois and Smith (1989) investigated another component of the CVCC system: POSNAV. Two different POSNAV prototypes were examined, one with a grid map display and the other with a terrain map display. The grid map display presented only the Universal Transverse Mercatur (UTM) grid lines and no terrain or man made features. The terrain map had the ability to display roads, vegetation, terrain contour lines, and UTM grid lines. The main focus of their examination was the performance of tank crews and platoons using the two prototypes compared to those using conventional navigational techniques. Their results suggested significantly better performance with the POSNAV system compared to conventional techniques although few differences in performance were detected between crews and platoons using the grid map and terrain map displays.

Du Bois and Smith (1989) examined soldier reactions to the POSNAV interface for the two prototypes using a questionnaire with rating scales for various features of the interface and open-ended questions to solicit comments. Overall, the crews who used the POSNAV system indicated positive reactions to the POSNAV SMI for both the grid and terrain map display. Soldiers generally reported that the functions were easy to use, that the display was easy to read, and that no trivial or non-useful functions were included on the display. The navigation route designation function and the map display with own-vehicle icon were regarded as particularly useful. In addition, crews indicated that the location of the commander's POSNAV display in the tank--to the right of the gunner's primary sight extension (GPSE)--was acceptable and that the POSNAV display allowed them more time to acquire targets. The crews also indicated that drivers served a more important role in land navigation with the POSNAV system, due to the vehicle commander's ability to delegate more responsibility to the driver.

Soldiers frequently offered two suggestions for improving the POSNAV SMI. They included: 1) adding a system indicator light or acoustic signal to (a) indicate to the vehicle commander that a route waypoint has been received by the driver's POSNAV display and (b) that an entry was input incorrectly; and 2) include the locations of other friendly elements on the display. Further, crews using the grid map prototype indicated a preference for a map display with terrain features, especially contour lines. Crews with the terrain map prototype indicated that contour lines should include elevation indices to ensure that soldiers can distinguish between hills and depressions. Findings incorporated into the CVCC include POSNAV for all friendly vehicles and the terrain map.

Du Bois and Smith (1990) also examined IVIS, another component of the CVCC system. This investigation compared the performance of crews and tank platoons equipped with a prototype IVIS to those using conventional command and control and navigation tools. Their results were similar to those reported for POSNAV with IVIS units consistently outperforming units with conventional tools.

As part of the IVIS investigation, vehicle commanders were asked to complete a questionnaire on the IVIS interface. The questionnaire asked commanders to indicate their level of agreement with statements about features of the IVIS SMI using a rating scale. In general, commanders expressed positive reactions to the IVIS interface. They indicated consistent support for IVIS and agreed that IVIS improved their performance and should be included in future tank upgrades.

More specifically, the commanders were satisfied with most of the IVIS report formats and consistently reported a preference for sending reports digitally with the IVIS rather than over a radio. However, they felt that they received too many IVIS reports and spent too much time reading them. Vehicle commanders were satisfied with the map features, overlay functions, and the readability of the map display, but felt that the IVIS display was too small and warranted enlarging. They were also satisfied with the procedures for entering, updating and relaying IVIS route waypoints, and the mutual POSNAV capabilities. Mixed reactions were received to the touch screen, visual and auditory cues and decision rules used to prioritize IVIS reports, and the ability of IVIS to improve target acquisition.

Commanders also offered recommendations for improving the design of the IVIS interface. They included: adding a capability to tailor report routing so reports could be sent to specific commanders (not just to higher, lower, or all tanks); incorporating an improved system for prioritizing and/or filtering reports to deal with report overload; incorporating an acknowledgement message for successful report transmission and receipt; and providing greater flexibility in report functions.

User-based evaluation has been an important part of the CVCC development process. The present evaluation was undertaken to identify critical CVCC SMI issues by determining the usability and usefulness of system components. The next section details the method by which this research was conducted.

Method

Subjects/Participants

A total of 105 U.S. Army personnel--20 commissioned officers, 15 noncommissioned officers, and 70 enlisted men--served as participants in the SMI evaluation, over a period of five weeks. These participants were scheduled in groups of 21 each week. All were males stationed at Fort Knox, Kentucky and ranged in age from 18 to 41. Most participants were assigned to units at Fort Knox, including recent graduates of the Armor Officer Advanced Course or the Armor Officer Basic Course.

In response to a troop support request from ARI, the supporting troop units provided participants in groups comprised of seven vehicle commanders and fourteen other crewmembers (NCOs and enlisted personnel) to serve as gunners and drivers. Unit leaders determined who would participate in the evaluation. All participants were required to hold armor Specialty Skill Identifiers (SSIs) or to be currently qualified in armor Military Occupational Specialties (MOSs).

All participants received a briefing explaining the purpose of the evaluation and the role they played in it. Each participant signed a Privacy Act Statement after listening to the provisions for ensuring his privacy and his right to withhold any information he might desire. The potential uses of the data to be collected were also explained.

Configuration of Test Company

Each week's group of subjects was organized into a test company forming the core of the evaluation. The company modeled a tank-pure, three-platoon future CVCC-equipped battle tank maneuver element. The 2nd platoon was completely manned, while the 1st and 3rd platoons each contained one manned and three semiautomated vehicles. The crew structure (vehicle commander, gunner, driver) for a manned simulator was always the same. The loader position was represented by a research assistant (RA) who replenished autoloader ammunition and recorded observational data.

Since it was not possible to consistently obtain intact crews, reconstituted crews were created, by the research team, at the start of the week. This eliminated any benefits which might have accrued to intact crews who participated.

The seven manned simulators were assigned to the following company positions: company commander, three platoon leaders, 2nd platoon vehicle commanders (platoon sergeant, platoon sergeant's wingman, and platoon leader's wingman). To fill out the 1st and 3rd Platoons, three semiautomated vehicles were *tethered* to each platoon leader's simulator (Tethered vehicles are groups of semiautomated vehicles coupled with the manned vehicle who serves as commander of their unit. Tethering allows semiautomated vehicles to move about independently while maintaining the appropriate formation in relation to that manned vehicle). The platoon leader could exert limited control over these tethered vehicles. Software-controlled parameters largely determined their positioning and movement, based on the platoon leader's location and movement. A research team member in the Exercise Control Room role-played the tethered vehicle commanders for purposes of radio communications. Software routines generated digital reports from the tethered vehicles to simulate realistic company-level CCD message volumes.

In company staffing, the senior commissioned officer of the group served as company commander (Co Cdr). The research staff randomly assigned the remaining three officers to the three platoon leaders (Plt Ldr) positions. The three senior NCOs were then assigned to the platoon sergeant and wingmen positions based on rank and time in grade. The remaining participants were divided into gunners and drivers, based wherever possible on their current duty positions. Gunners and drivers were then randomly assigned to crews, with the provision that no crew contain members who normally served on the same crew.

Test Facilities and Materials

Simulator Facilities

Seven research and development (R&D) future CVCC-equipped tank simulators in the Fort Knox CCTB facilities supported this evaluation. Table 1 lists the simulator capabilities which characterized the CVCC configuration. The key features included the Command and Control Display (CCD), POSNAV, the CITV, the Commander's Control Handle, Vision Blocks in all three crew stations (vehicle commander, gunner, driver), Grid Azimuth Indicator, Odometer, Laser Range Finder (LRF), Gunner's Primary Sight (GPS), GPS extension (GPSE) in the commander's station, Turret Reference Display, the Autoloader, and simulated Single Channel Ground Airborne Radio System (SINCGARS) without terrain modeling capability.

Command and Control Display configuration. The CCD is pictured schematically in Figure 3. Du Bois and Smith (1990) have described an earlier version of the system (IVIS). Modifications incorporated in the current version are reflected in the descriptions below. The 10.25-inch diagonal cathode ray tube (CRT) displaying the CCD was mounted to the right of the vehicle commander. A 7 X 5.75 inch rectangular working area of the CRT face comprised the primary user interface. Five functional sections organized this interface: (a) full-feature, five-color Tactical Map (4.5 X 5.12 inches) with directional own-vehicle icon; (b) Information Center displaying date/time group, own grid location, own vehicle heading, and own call sign; (c) fixed array of dedicated soft-switch menu keys accessing specific functions; (d) working menu area displaying queue/file listings, sub-menus, and selected functions; and (e) message receipt alert key.

Table 1

Basic Capabilities of R&D Simulator Configurations

Navigation
CCD
Grid azimuth indicator
Laser Range Finder (LRF)
Odometer
Paper map with acetate overlays
POSNAV
Vision blocks
Waypoint Transmission
Target acquisition/engagement
CITV
Identification Friend or Foe (IFF)
Target Designate
Target Stack
GPS/GPSE (with thermal, 3X/10X, LRF)
Turret reference display
Vision blocks
Communications
CCD digital reports
CCD Radio Interface Unit
Intercom (for crew communication)
SINCGARS radio (voice)

Table 2 lists the C^3-related capabilities of the CCD. Smith (1990) describes the functional features of the CCD. A brief overview of the system follows.

Map functions. The basic Tactical Map was a Universal UTM grid representation of the terrain surrounding the tank's location, from an overhead perspective. Digital data in the SIMNET terrain database constituted the basis for all resident map graphics. Four map scales were available at all times--1:25,000, 1:50,000, 1:125,000, and 1:250,000--with at least a few seconds processing time required for rescaling. The CCD provided several additional features for optional selection by the vehicle commander: contour lines, rivers, roads, vegetation, and UTM grid lines, all of which were color coded. Also, the system could display graphic tactical map overlays received digitally.

Several map scroll functions enabled the vehicle commander to control positioning of the map in relation to his tank icon. The basic scroll function maintained the icon in the center of the map, scrolling the map as the tank moved. An option was to lock the map in position, maintaining a view of the same terrain segment regardless of where the tank moved. The vehicle commander could position his tank icon in an off-center location while the map scrolled under the tank icon. Finally, he could reposition the map to show a new terrain segment, allowing him flexibility to inspect icons or terrain features of interest.

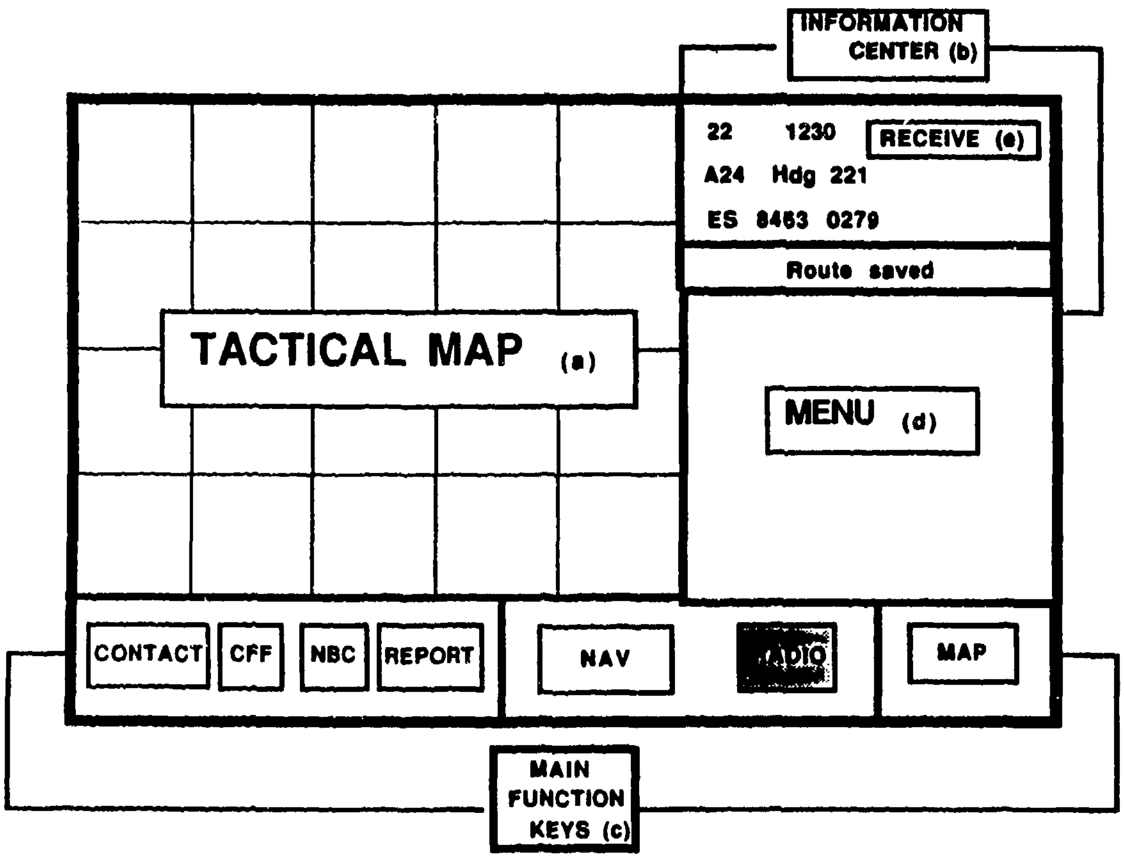

Figure 3. Schematic Drawing of the CCD user interface, with the five primary functional areas labelled (letters designating functional areas are described in text).

The Tactical Map could display key symbols (icons) representing battlefield information. These included report-based and route-based icons. Reports being prepared generated icons on the map (e.g., CONTACT reports generated enemy vehicle icons). Upon completing the report, the vehicle commander could post these icons to the map. Waypoints generated under Navigation functions appeared on the map with connecting lines, forming graphic routes. The Tactical Map automatically displayed icons representing all friendly vehicles located on the terrain segment currently displayed. This was labelled the "mutual POSNAV" feature. Finally, map icons (e.g., minefield symbols) signalled reports which were received digitally. These icons remained on the map until the vehicle commander took action on the report or until the report automatically transferred to the "old" file (a filing system based on report type). Exceptions to the latter rule existed: when CONTACT and INTELLIGENCE reports transferred to their respective old file, their icons remained on the map.

Table 2

C^3 Capabilities of the CCD

Navigation
Directional icon (own vehicle)
Driver's Steer-to-Display
Friendly vehicle locations (POSNAV)
Graphic overlays
Grid map
Own vehicle location (grid and icon)
Report-based icons
Route waypoints
Terrain map
Transmission of routes
Waypoint Autoadvance
Communications
Digital report preparation
LRF input to reports
Receive/relay graphic overlays
Report-based icons
Send/receive/relay digital reports
General Characteristics
Color display
Thumb Cursor control
Touch Screen control

<u>Navigation functions</u>. The CCD enabled the vehicle commander to create and modify routes for navigation and to send route information to his driver. In addition, the CCD permitted any vehicle commander to transmit a route digitally to other vehicles in his unit. Routes were generated by designating up to six locations on the map (waypoints). An icon for each waypoint appeared on the map, while lines connected successive waypoints. The vehicle commander could manually send each waypoint to his driver or an Autoadvance option could be used to automatically send the next waypoint after the previous had been reached.

The Navigation subsystem included a Steer-to-Display in the driver's compartment, mounted to the right of the steering column (the T-bar). Figure 4 depicts the driver's T-bar. To the right of the T-bar is the Steer-to-Display which presented alphanumeric information about the tank's current and required heading as well as distance from the current waypoint. The display incorporated a graphic indicator with a pointer showing how the driver should steer to reach and maintain the proper heading, represented by the 12 o'clock position. Note in Figure 4 that the pointer is approximately at the four o'clock position, thus the deviation (DEVN) is 111 degrees. Given this situation, the driver would neutral steer the tank 111 degrees to the West (at which time the pointer would be at the 12 o'clock position) and drive the eight kilometers to the waypoint, maintaining the 12 o'clock pointer position.

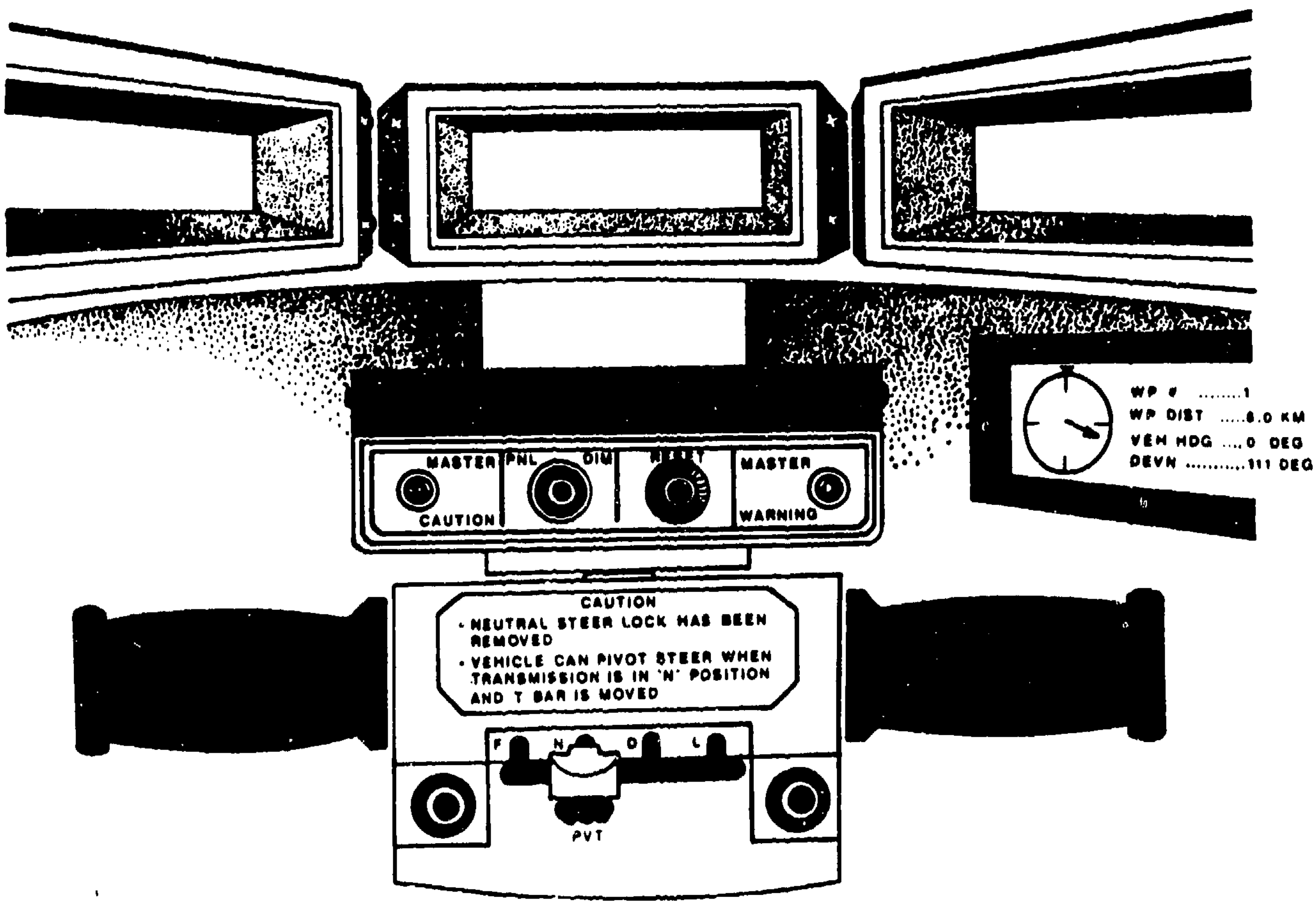

Figure 4. Drawing of the driver's T-bar, showing the Steer-to-Display on the right.

Also of value in navigating and positioning was the directional own-tank icon displayed on the CCD tactical map. This helped maintain proper orientation and direction of movement. Additionally, both UTM grid location and grid azimuth heading were available in the CCD information center.

Report functions. The CCD supported preparation of reports by means of menu-driven screen forms. The vehicle commander was able to prepare any of the nine types of reports available on the CCD by filling in fields appearing in the working menu area. Table 3 lists these report types along with the number of fields and pages in each. The vehicle commander could call up CONTACT, CALL FOR FIRE, and NUCLEAR-CHEMICAL-BIOLOGICAL (NBC) report forms directly from the fixed menu keys. The remaining report forms required him to call up the Report menu first, then choose a report type from the options appearing in the working menu area.

Fill-in fields usually called for selecting inputs from option sets provided by the CCD. Fields dealing with location or heading information called for grid inputs from the tactical map or from lasing to a vehicle or terrain point with the CITV. Blank fields were permitted. Since typically only four or five fields could fit in the working menu area, four of the reports required more than one "page" for complete presentation, the final page being a summary of all fields.

Table 3

Report Preparation Forms Available on the CCD

Report Type	Number of of option-input fields	Number of of grid-input fields	Number of Pages
CONTACT	4[a]	4[a]	1
CALL FOR FIRE	1	1	1
ADJUST FIRE	3	1	1
SPOT	9	2	3[b]
SHELL	2	1	1
SITUATION	8	2	3[b]
AMMUNITION	5	0	1
INTELLIGENCE	8	6	4[b]
NBC	7	2	3[b]

[a] - Up to four paired ID-location fields could be filled in.
[b] - Includes a final summary page.

At any time the vehicle commander could leave a report preparation screen without completing or sending the report. That report preparation screen would remain "behind" any subsequent screens without loss of information and could be returned to for later completion. He might, for example, leave to prepare another type of report or go to the MAP function to change scales. Multiple types of reports could be open at the same time, but only one report of a given type (e.g., CONTACT) could be open at any time. No more than one report could be visible on the screen at a given moment. The vehicle commander could complete a report (and thereby dispose of that report form) by either deleting, cancelling, or sending it, using a sequence of soft-switch presses.

Digital report transmission. A simulated radio interface unit (RIU) enabled the vehicle commander to transmit digital reports prepared on the CCD. Co Cdrs and Plt Ldrs had access to two radio nets: Co Cdrs had the battalion and company nets, while Plt Ldrs had the company and their platoon nets. Only the platoon net was available to the platoon sergeant and the wingmen. A routing menu offered the option of sending any report on any radio net available for the vehicle commander's use, including simultaneous transmission if two nets were available. For example, a Plt Ldr could send a report to the vehicle commanders within his platoon (platoon net), to the Co Cdr and the other Plt Ldrs (company net), or to all of them at the same time. A default net (based on transmission direction--upward or downward) existed for each report type. If a Co Cdr or Plt Ldr sent or relayed an INTELLIGENCE Report, a FRAGO, an Overlay or a Route, the default was the downward-going net (the platoon sergeant and wingmen had no downward-going net). For the remaining reports the default was the upward-going net. Upon transmission, a report copy automatically transferred to the sender's appropriate old file, from which it could be later retrieved and resent. A "MESSAGE SENT" confirmed transmission, displayed in the Information Center, but there was no feedback indicating that addressees had received or read the report.

When a vehicle commander received a report, three cues appeared at once: the message receipt alert key (located in the upper right corner of the CCD) lighted up, an audible cue sounded in the vehicle commander's headset (three tone beeps for a high priority report, one beep for others), and an icon appeared on the tactical map (blinking for the first five seconds). A report remained in the receive queue for five minutes, as did its associated icon remain on the map. As high priority reports (ADJUST FIRE, CALL FOR FIRE, CONTACT, FRAGO, INTELLIGENCE, and NBC--report priority being based on immediacy of information) arrived, they went to the head of the queue. Activation of the RECEIVE key called up the Receive Queue, listing the report type, originator, and time received for each report, enabling the vehicle commander to select a report for display in the working menu area. Up to five reports were displayed in the Receive Queue at a time, but it could be scrolled forward and backward to view the entire contents.

If the vehicle commander failed to retrieve a report from the Queue within five minutes, the report automatically transferred to that report-type old file (unless the vehicle commander was viewing the report when the five minutes elapsed). When transferring to their old file, CONTACT and INTELLIGENCE reports automatically posted an icon to the map. For other reports, the associated icon, if not manually posted, disappeared from the map.

Once the vehicle commander selected a report to read, he could review it at his own pace. In the case of a multi-page report, only the summary page appeared. When ready to terminate his review, he could cancel and file the report (with an option to post to the tactical map an icon representing it), he could relay it (see below), or he could delete it. Unless he deleted it, he could subsequently retrieve the same report as many times as he desired.

If the vehicle commander decided to pass a report along to other members of his unit, he could exercise the option to relay it (there was no capability to edit reports). Relaying a report involved the same steps as transmitting one. The same options for routing were available. The system did not limit the number of times a given report could be relayed or sent.

Control device. The vehicle commander controlled the operation of the CCD by means of a cursor appearing on the face of the display screen. He selected menus and functions by positioning the cursor on the desired key. The CCD afforded the vehicle commander the option of manipulating the cursor position by touching with his finger the face of the touch-sensitive screen or by using a thumb control mounted on his control handle. Touching the screen automatically jumped the cursor to the new position designated by the finger's contact with the screen. When satisfied with the cursor position, the vehicle commander removed his finger from the screen. This action initiated the menu or function corresponding to the key on which the cursor rested, or resulted in a grid location input to a report if the cursor was located on the map. The cursor was offset from the touchpoint to enable the vehicle commander to see the cursor location.

When operating the thumb control, the vehicle commander could move the cursor in virtually any direction at a variable speed. With the cursor resting on the desired key, release of the thumb control initiated the corresponding menu or function.

Utility functions. The CCD provided a small set of utility functions with which to manage prepared and received reports. The automatic transfer of reports from the Receive Queue to their respective old file was one such function. The vehicle commander could also delete reports which he created, both during preparation and after transmission, as well as any reports he had received. The latter action could be accomplished without reviewing the contents of the report or after it had been filed. Deletion resulted in no record of the contents. To declutter the tactical map, the vehicle commander could delete icons one at a time or he could select a menu option to delete all icons older than a specified time.

Commander's Independent Thermal Viewer configuration. The CITV afforded the vehicle commander a battlefield viewing capability and an independent LRF. In terms of tactical utility, the diverse functions of this system spanned navigation;

battlefield surveillance; target acquisition, identification, and management; and fire control. Table 4 lists the functional capabilities of the CITV.

Table 4

Capabilities of the CITV

Autoscan
Gunner's Line of Sight (GLOS)
Identification Friend or Foe (IFF)
Independent laser range finder
Independent thermal search
Manual Search
Own Vehicle Icon (directional, all parts moving)
Target Designate
Target Stack
3X and 10X Magnification
White-hot and Black-hot Polarity

Mounted directly to the front of the vehicle commander, the CITV arrayed control switches around three sides of a central display screen (Figure 5). Switches on the right margin of the interface were nonfunctional. The vehicle commander controlled operation of the CITV via inputs through the functional switches and through push buttons on his control handle. The control handle was also used to control manual movement of the CITV sensor (for scanning and sector set limits). The interface components entailed: (a) rectangular (6.5 X 5.88 inches) monochrome CRT display screen with own-vehicle icon and sighting reticle; (b) power switch with OFF, STANDBY, and ON positions (three-position toggle); (c) push-button selector switches for basic mode (CITV, GPS); (d) push-button selector switches for operational mode (AUTOSCAN, MANUAL SEARCH, GLOS); (e) two-position push-button switch for polarity (WHITE-HOT, BLACK-HOT); (f) Autoscan control switches for setting sector limits and adjusting scan rate; (g) vehicle commander's Target Stack display with four push-button target selector switches and ON/OFF push-button switch; (h) gunner's Target Stack buttons similar to the vehicle commander's; (i) control handle (depicted in Figure 6) with push buttons for switching magnification (3X, 10X), operating the laser, and designating targets.

Quinkert (1988) has described the functional features of the CITV. The SIMNET CITV User's Guide (Heiden, 1989, pages 7-15) explains the operating features. (NOTE: The physical layout of the user interface shown in the User's Guide is distinctively different from the configuration used in this evaluation. The operating procedures were the same.) Summarized below is an overview of the system functions.

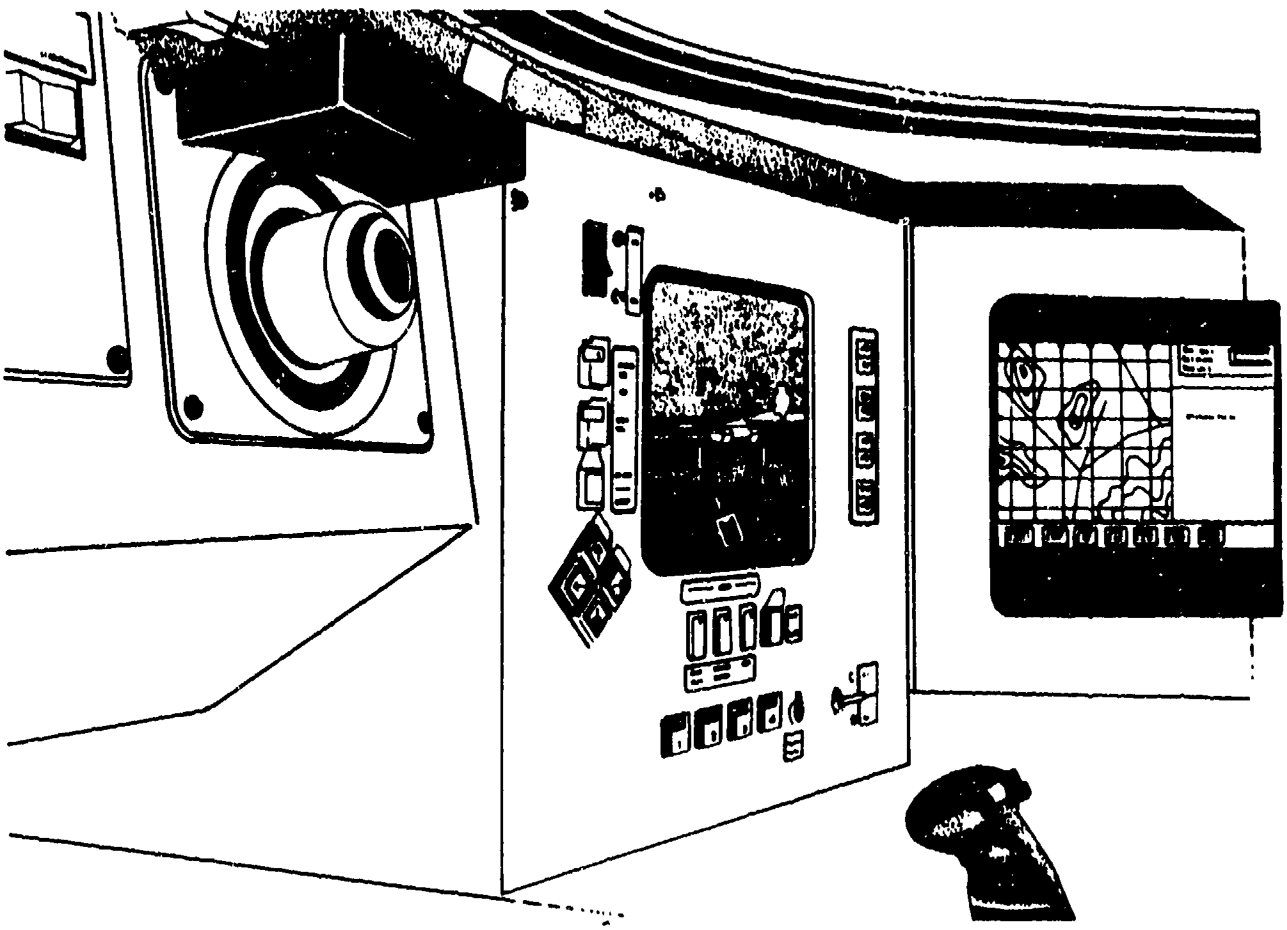

Figure 5. Drawing of the vehicle commander's crewstation in a manned tank simulator, with the CITV in the center.

Basic modes. In the GPS mode, the CITV was functionally inactivated, with the last active scene from the sensor remaining static on the screen. Requiring the vehicle commander to use his GPSE for viewing, this mode enabled him to override the gunner in moving the turret/gun tube and firing. The CITV mode permitted the vehicle commander to select three types of surveillance--GLOS, Manual Search and Autoscan. The GLOS mode slaved the CITV line of sight to the main gun alignment, except when the vehicle commander depressed his palm switch to activate Manual Search. The slaved alignment provided a view overlapping the gunner's view while enabling the vehicle commander to operate his own laser and change magnification and polarity. The Manual Search and Autoscan capabilities, both providing independent surveillance, are discussed below. The vehicle commander could not fire the main gun from the CITV mode.

In all CITV modes the display screen presented optional fields of view: wide field (3X magnification: 7.5 X 10 degrees) and narrow field (10X magnification: 2.5 X 3.3 degrees). In providing uninterrupted horizontal sweep capability, the system afforded a 360 degree field of regard. The vertical expanse of the field of regard ranged from +20 to -12 degrees. According to his preference, the vehicle commander could select White-Hot or Black-Hot display options. In White-Hot mode, warmer objects within the field of view appeared "white" against a darker background. In Black-Hot mode, warmer objects appeared black against a lighter background.

The own tank icon present on the display screen depicted the direction of the turret/gun and CITV. The CITV indicators included the CITV's LOS as well as the Autoscan sector limit markers. The entire icon rotated to represent the proper grid azimuth heading of the tank hull. The CITV tank icon was consistent with the CCD own tank icon.

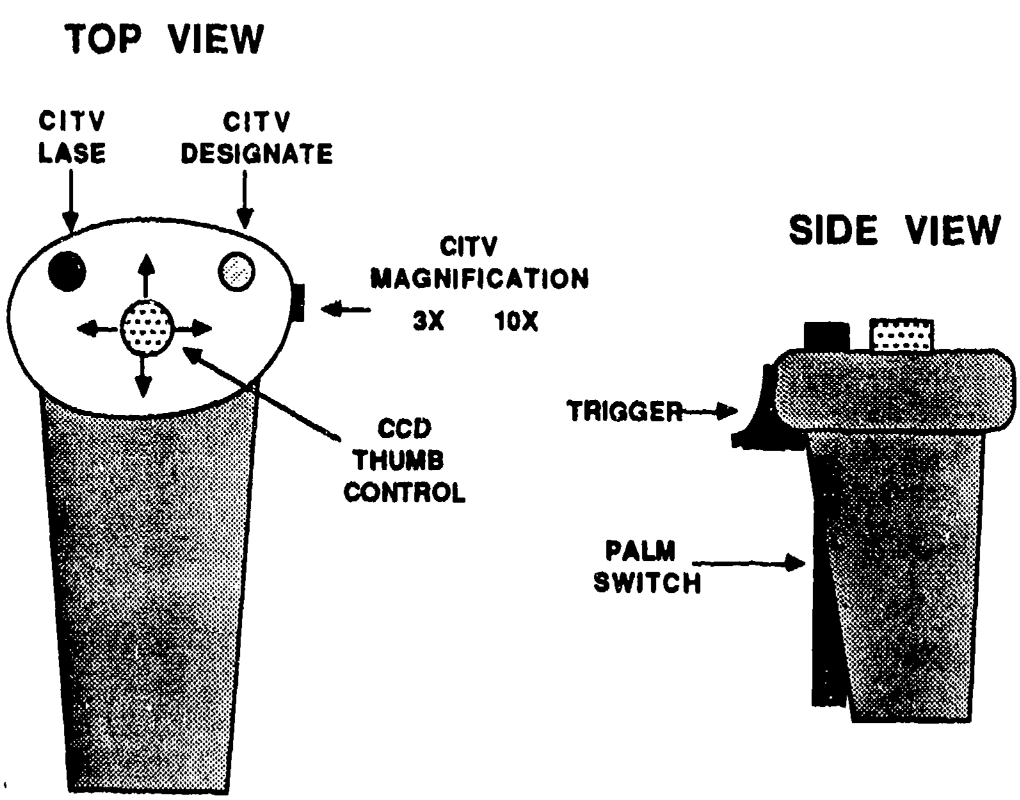

Figure 6. Drawing of the commander's control handle, with the functions labelled.

Manual Search. In selecting Manual Search, the vehicle commander could control the CITV's line of sight manually by manipulating his control handle. Both direction (horizontal, vertical, and oblique) and speed of movement could be controlled simultaneously. This mode allowed the vehicle commander to vary at will his pace and pattern as he searched for targets. It preserved access to other control options such as magnification, polarity, and target designation.

Autoscan. Autoscan permitted the vehicle commander to sweep automatically the CITV's line of sight back and forth across a specified sector at a set rate of speed. The search pattern required no input from the vehicle commander once initial parameters were set. Setting or resetting left and right sector limit markers defined the portion of the field of regard to be scanned. To adjust scan rate, the vehicle commander could increase or decrease the current rate, which began at a default value upon initialization. The entire 360 degree field of regard could be selected as the scanning sector, if desired. As with Manual Search, Autoscan maintained availability of secondary control options such as polarity, magnification, and target designation. The latter function required the vehicle commander to activate a temporary Manual Search option by depressing his palm switch.

Independent Laser Range Finder. The CITV system included a laser capability independent of the standard LRF. The vehicle commander could exercise this capability in GLOS, Manual Search, and Autoscan modes; lasing in the latter mode required interruption of scanning to stabilize the sight picture. Each lase produced a range-to-target reading in meters, displayed in the lower left corner of the display screen; this reading could indicate flawed determinations and double returns. Lasing also supported the IFF function, which had an 85% accuracy rate and generated symbology characterizing the target as friendly, enemy, or uncertain. This symbology appeared in the upper left portion of the display.

Target Designate. In the Manual Search and Autoscan modes, the vehicle commander could use the Designate function to quickly hand off a target to his gunner. Having identified an enemy target for immediate engagement, the vehicle commander pressed the DESIGNATE button on his control handle. This rapidly slewed the main gun to the CITV's line of sight, overriding the gunner's controls. The vehicle commander then could hand off the target.

Target Stacking. The CITV configuration incorporated a target management feature referred to as Target Stacking. In both the Manual Search and Autoscan modes, the vehicle commander could use this feature to cue the gunner about available targets. After lasing to and identifying an enemy target the vehicle commander pressed one of four buttons to mark the target's location. He could cumulate up to four targets in the stack. The vehicle commander placed targets in the stack in priority order (number one being highest priority). As the vehicle commander stacked targets, cuing lights on the gunner's display came on and, for each target, two LEDs indicated the relative position of the target with respect to the direction of the main gun (left, right, or centered). The gunner could use these indicators to anticipate the direction in which the turret would slew after pushing a target stack button. After the gunner engaged a target selected from the target stack, it dropped from the stack (lower priority targets did not automatically move up in the stack after higher priority targets had been selected).

Radio nets. The simulated SINCGARS radio system serviced five voice radio nets--battalion, company, and three platoons. The manned simulators connected to these nets in a doctrinally realistic arrangement. The Co Cdr, Plt Ldrs, and platoon sergeant accessed two nets each, while the two wingmen accessed only one. An RIU linked the CCD with the SINCGARS system to enable transmission of messages via digital burst technique. The voice radio net scheme (Figure 7) defined the automated routing options for each vehicle commander except the platoon sergeant, who could transmit CCD messages on only the platoon net.

Test Scenarios

Test scenarios consisted of a series of realistic battles designed to evaluate tank companies as they maneuvered, fought, and communicated in a simulated combat environment. The scenarios were based on outlines developed by the Armor School's Directorate of Combat Developments (DCD) and approved by Command and Staff Department. They were set on terrain surrounding Fort Knox, Kentucky, and were designed to take approximately two hours and thirty minutes for execution, exclusive of initial planning time and break periods.

To provide a reasonably broad range of performance requirements, two scenarios were developed: a movement to contact/hasty attack operation and a delay/hasty defense operation. These were chosen because they provide situations that: (1) require units to maneuver while in contact with an opposing force (OPFOR), (2) require rapid responses to changing situations, and (3) provide objective markers of mission completion. Also, prior research had shown that both types of missions are suitable for execution and quantification within the SIMNET environment. Each scenario was divided into three phases which provided multiple opportunities, within each scenario, for performance assessment.

Automated Data Collection and Analysis System (DCA)

The CCTB DCA provided automated data recording, reduction, management, and analysis functions. Within this system, automated data collection occurred in the real-time, digital domain, storing information packets broadcast by each simulator over an Ethernet. Data packets were generated by the user's

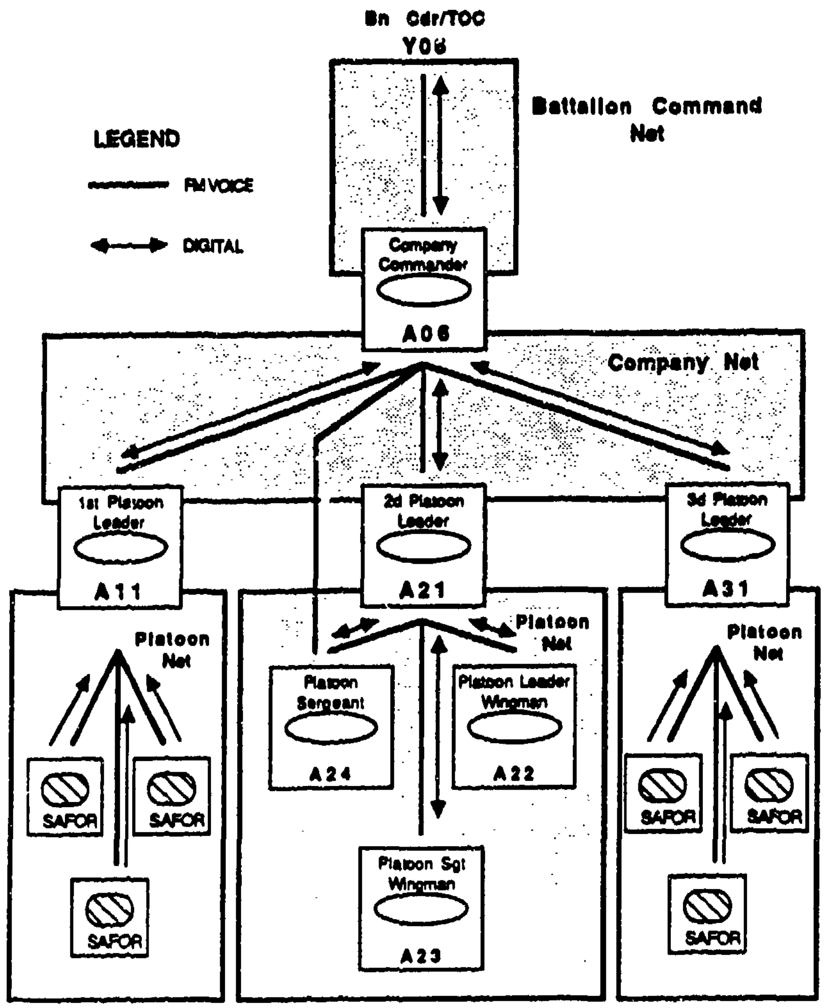

Figure 7. Schematic representation of SINCGARS radio net configurations, showing the battalion command net, the company net, and the three platoon nets. (Each square with a call sign (A06, A11, etc.) represents a manned M1 simulator; the blocks labelled "SAFOR" represent control room radio stations where a controller role-played platoon vehicle commanders.)

activation of the system (e.g., a CCD soft-switch press) or by timed cycles (e.g., sampling every 30 sec). Equipment usage measures which addressed the SMI research issues were obtained via automated data collection and are presented in Table 5. Table entries represent average per phase measures.

Manual Data Collection Materials

The manual data collection materials for the SMI evaluation were a set of self-report questionnaires. These questionnaires were developed to assess participants' perceptions

Table 5

Automated Equipment Usage Measures

CCD Usage Measures
Percent of Inputs by Touch Screen
Number of Navigation Routes Activated
Percent of Time in Each Map Scale
Percent of Grid Inputs to Reports by Laser Device
Median Number of Report Icons on the Tactical Map
Total Number of Reports Originated
Percent of Reports Retrieved from Receive Queue
Percent of Reports Retrieved
Percent of Reports Relayed, by Report Type
Number of Reports Relayed
CITV Usage Measures
Percent of Time in each Operating Mode
Percent of Time in each Viewing Mode
Number of Times Designate Used
Number of Targets Entered in Target Stack

of the CCD and CITV by inquiring about usability, usefulness, and suggestions for improvement. This section contains a description of each questionnaire, the method of construction, testing, and administration.

Four SMI questionnaires were developed: two for vehicle commanders; one for gunners; and one for drivers. Each focused on design characteristics that might enhance or degrade mission performance. In each questionnaire, participants rated a series of statements using a bipolar 5-point scale ranging from "Strongly Agree" to "Strongly Disagree". The statements were roughly split between negative and positive sentence construction, with some equipment usage statements employing a neutral construction. Appendix A contains copies of the questionnaires.

Questionnaire Development

The development of questionnaires was an iterative process which began with self-report instruments used in previous SMI evaluations. Revisions to questionnaires were based on modifications to the CVCC components resulting from the previous design and evaluation efforts, as well as integration of the system components.

Questionnaires were tested during each of the evaluation's pilot tests, with reviews and revisions occurring between pilot tests. A number of scripted questions were posed to the participants, both as a group and individually, after they had completed each questionnaire. These questions dealt with the format and intelligibility of items as well as the content. Participants were asked to provide comments, including suggestions for additional items. Participants' responses were incorporated, where appropriate, into the questionnaires. The questionnaires then went through one or more review cycles followed by revisions, until being finalized after the last pilot test.

CCD Evaluation. The CCD Evaluation Questionnaire was developed for vehicle commanders. In addition to rating statements on CCD design and functionality, the CCD Evaluation contained a number of open-ended questions to obtain information not available with a rating scale. In these questions vehicle commanders were asked which features of the CCD improved or degraded combat mission performance, their preferred mode of input, and suggested improvements to the CCD.

CITV Evaluation. The CITV Evaluation Questionnaire was developed for vehicle commanders. To capture additional information, this questionnaire also contained a number of open-ended questions. In these questions, vehicle commanders were asked how they used the CITV in the offensive scenario and in the defensive scenario; for novel uses of the Target Stacking function; and for suggested improvements to the CITV.

Driver's Evaluation. The Driver's Evaluation Questionnaire contained statements concerning the Driver's Display as well as vehicle commander and driver coordination requirements resulting from its use. It also included three questions addressing the adequacy of training. Given the relatively small amount of new equipment on which drivers had to be trained, their training program was brief. The results of the training questions can be found in Atwood, et al., in publication. Open-ended questions asked drivers to enumerate problems encountered using the equipment as well as suggested improvements.

Gunner's Evaluation. The Gunner's Evaluation Questionnaire assessed functional aspects of the Target Stack buttons as well as the impact of the vehicle commander's additional target acquisition capabilities on vehicle commander and gunner interaction. Gunners also answered three questions about the adequacy of the training they received. As with the Driver's Evaluation, results of the gunner training questions are presented in Atwood, et al., in publication. This questionnaire also asked gunners (via open-ended questions) to identify problems encountered using the new functions and to suggest useful fire commands to be used by their vehicle commander in conjunction with the Designate function.

Procedures

This section provides an overview of the data collection and analysis procedures for the SMI evaluation. Atwood, et al. (in publication) describe the two and one half days of training received by participants, while Leibrecht, et al, (in preparation) describe the testing procedures which characterized data collection for the remainder of the week.

Automated Data Collection

Collection of automated data was handled by the CCTB site support contractor: Bolt Beranek and Newman, Inc. (BBN), using the DCA system. Standard DCA procedures were employed in collecting automated data. All test scenarios were recorded on magnetic tape for subsequent reduction and analysis.

Analysis of Automated Data

Automated data were available by scenario type, phase and duty position. The data for each scenario type were analyzed separately due to the very different nature of the scenario types--largely stationary for defensive, largely on the move for offensive, for example. Prior to analysis the automated SMI data were combined across phases and a duty position variable was created for analysis purposes.

No attempt was made to compare data for the two scenario types, statistically or otherwise, because of inherent differences which preclude comparison. For example, the offensive scenario was a movement to contact--an average of 25.4 km travelled per phase versus an average of 5.2 km per phase during the defensive scenario. During the offensive scenario the enemy was encountered on the move and in platoon-sized units, whereas the enemy was mostly encountered from a stationary position and in battalion-sized units during the defensive scenario.

Prior to analysis, data values were averaged across the three scenario phases to create a single value for each SMI automated measure. The primary reason for this was to normalize measures. Each phase within a scenario differed in the number of enemy vehicles encountered and in some cases the number of enemy engagements. These differences have a potential effect on automated measures of equipment usage. By averaging across phases a representative measure of equipment usage was obtained.

A duty position variable, with three levels, was created in order to investigate the possible effect of duty position on CVCC usage. Differential use based on echelon may have implications for future design. As higher echelons are incorporated in evaluations, we may find it necessary to tailor CVCC functions to the demands of higher echelons.

Vehicle commander duty position levels were: **Co Cdr**; **Plt Ldr**, including the 1st, 2nd, and 3rd platoon leaders; and **TC** (tank commander), including all remaining 2nd platoon vehicle commanders. This last level included platoon sergeants (Plt Sgts) primarily because their digital radio net structure was identical to that of TCs (platoon net only). Conventionally, however, the Plt Sgt's radio nets include the company net, and being the most experienced vehicle commander in the platoon, he serves as the Plt Ldr's replacement should it become necessary. Thus, the Plt Sgt might otherwise be included with Plt Ldrs.

The Statistical Package for the Social Sciences for the IBM Personal Computer (SPSS/PC+[2]) was used for all data analyses. Descriptive statistics, using the MEANS procedure, were computed for each of the SMI automated measures by duty position, for each scenario type (offense, defense). These data were then subjected to analyses of variance to determine the effect of duty position. Factorial analyses were performed using the SPSS MANOVA (Multivariate Analysis of Variance) procedure, which includes provisions for univariate ANOVA, testing of underlying assumptions, and comparisons among individual means. These procedures accommodate analyses on groups containing unequal numbers of subjects (Ns).

By their nature, automated data were subject to equipment malfunctions which required adjustments to the data prior to analysis. SMI data which were affected by equipment malfunctions were eliminated from analysis. Specific problems which gave rise to adjustments included: the inability to input grid locations to reports via the laser device, and CCD failure--resulting in re-transmission of all reports and graphic overlays.

Manual Data Collection

After each test scenario a debriefing was conducted, where the BattleMaster provided feedback on the company's performance. Participants' comments relating to CVCC utilization and suggestions for improvement were transcribed by a member of the research team.

Members of the research team administered SMI questionnaires to the participants (in a group setting) after the last scenario debriefing. For each SMI questionnaire, the administrator read a standard set of instructions tailored to the specific questionnaire. Participants were allowed as much time as needed to complete each questionnaire.

Questionnaire Analysis

The questionnaires produced two types of data: scale ratings and comments in response to open-ended questions. Descriptive statistics and response frequencies were computed for all questionnaire items using the SPSS MEANS procedure. Participant comments were categorized as follows.

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[2] SPSS/PC+ is a registered trademark of SPSS Inc.

There were two types of comments from the SMI open-ended questions: those in response to a direct question (e.g., "How did you use the CITV in offensive operations?") and those in response to a query for any additional comments. Each comment was examined and categorized. Within a direct question ("How did you use the CITV in offensive operations?") there were frequent multiple responses, e.g., monitor company formation, scan and identify targets. These responses resulted in two categories: Command and Control and Target Acquisition, respectively. Categories in this sense refer to groups of related responses or comments. The number of items within each category were tallied for presentation. The results of this categorization process were used to supplement and gain insight into the findings resulting from the automated and rating scale data. Comments were also used, where appropriate, to help make design recommendations.

Comments from debriefings were also categorized. Debriefing comments were recorded manually which often meant aggregating comments while recording (and trying to get the gist of a rapid, animated exchange). Given the second hand nature of the debriefing comments, no attempt was made to quantify them. They have been used to "fill out" or amplify results and recommendations.

The next section presents the results of the analyses and discusses their implications.

Results and Discussion

The presentation and discussion of SMI results answers the questions posed by two research issues: (1) "Is the CVCC a usable system; can it be operated with a minimum of effort and error?", and (2) "Is the CVCC a useful system; does it enable vehicle commanders to do the things they want and need to do?". These questions are first answered for the CCD and the reader is provided with an understanding of what contributes to the answers; the same is then presented for the CITV.

Many of the automated data are presented by duty position, levels of which are: (a) Co Cdr (N=5); (b) Plt Ldrs (N=15); and (c) TCs (N=15). Where duty position could be expected to affect equipment usage, ANOVAs were performed. Summary tables for reported F values are provided in Appendix B. The results of the questionnaires are presented in Appendix C, which contains response frequencies, means, and standard deviations. Select questionnaire items are presented in the text in the form of response distributions.

The CCD

Usability of CCD Input Devices

Are the CCD input devices, Touch Screen and Thumb Cursor, usable? To answer this question we investigated a measure of equipment usage, and questionnaire ratings. The **percent of inputs by Touch Screen** represents the proportion of the total number of inputs which were accomplished using the Touch Screen device. Inputs not made by Touch Screen were made using the Thumb Cursor (this measure excludes inputs to reports by CITV laser). The percentage of inputs effected by Touch Screen was 86.28 during the offensive scenario and 86.55 during the defensive. Standard deviations (Std Dev) were 31.80 and 31.13, respectively.

During debriefing sessions two Co Cdrs stated that they preferred the Thumb Cursor for input and their usage data reflect that preference. If these two Co Cdrs are excluded from the analysis the percent of inputs by Touch Screen rises to 91.50% (Std Dev = 24.14) in the offensive scenario and 97.41 (Std Dev = 5.61) in the defensive scenario.

These data indicate that the Touch Screen was the more usable and thus preferred input device. The small remaining percentage for input via the Thumb Cursor, as well as data from questionnaire ratings, indicate that the Thumb Cursor was not a particularly easy to use method.

The ratings in Figures 8 and 9 depict the response distribution, means, and Std Dev for evaluation items concerning the CCD input devices. These distributions support the automated

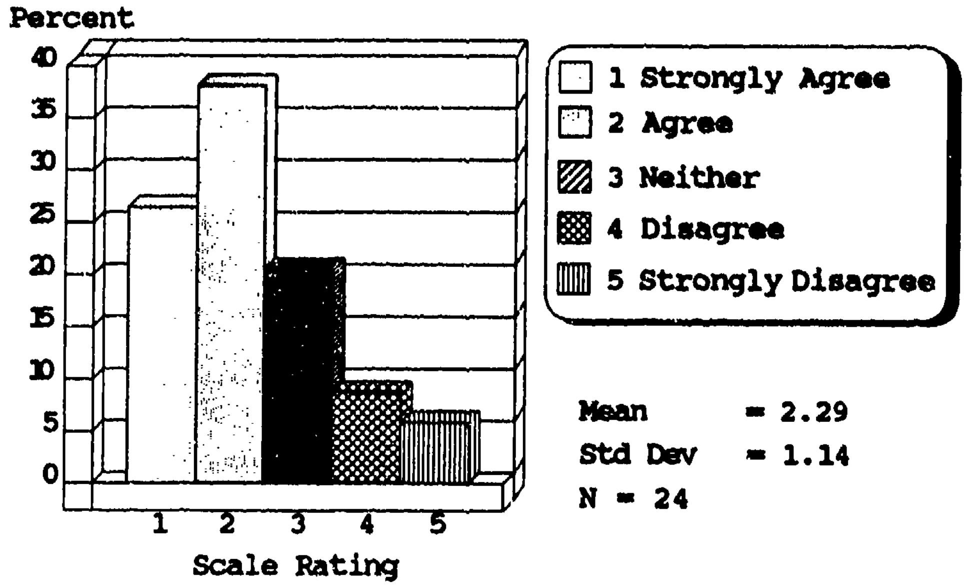

Figure 8. Vehicle commander response distribution: The Touch Screen made it easy to operate the CCD.

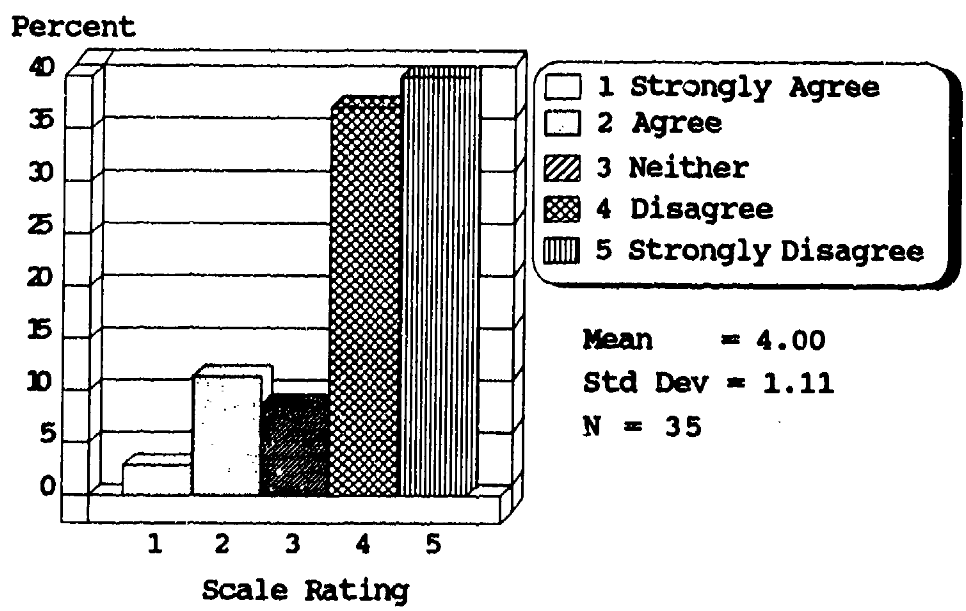

Figure 9. Vehicle commander response distribution: The Thumb Control was easy to use.

data findings. Almost 65% of commanders agreed that the Touch Screen made it easy to operate the CCD while only 14% agreed that the Thumb Cursor was easy to use. In fact, 77% disagreed with the latter statement.

When asked how they would prefer to make inputs to the CCD, 52% of vehicle commanders indicated "Touch" while only 17% indicated "Thumb"; 56% suggested methods other than the Touch Screen or Thumb Cursor to include trackball, keypad, mouse and light pen (note that multiple responses to open-ended questions were common and percentages frequently sum to greater than 100%).

Related to the usability of input devices, was a CCD evaluation item concerning the Commander's Override Control (also referred to as the control handle). The Thumb Cursor is located on the control handle as are the trigger, palm switch, and various CITV controls. Vehicle commanders were asked if the Commander's Override Control had too many functions. Figure 10 represents the response distribution. Less than 9% agreed that the handle contained too many functions and 60% disagreed. This finding indicates that suggestions made by Quinkert (1990) for redesign of the control handle have been successful in improving usability.

The data presented for CCD input devices indicate that the Touch Screen is the more usable and preferred method of input. However, it is important to consider redundant, alternate input devices to guard against an unaccessible system based on failure of the input device. This redundancy is currently provided by the Touch Screen and Thumb Cursor.

Usability and Usefulness of the Navigation Function

The Navigation function provided vehicle commanders the capability to create navigation routes (of up to six waypoints) by selecting locations on the Tactical Map with an input device or using the CITV laser. Each waypoint could be sent to the driver (individually or consecutively, using Auto Advance) and entire routes could be sent to other vehicle commanders. In order to determine if the Navigation function was usable and useful we investigated questionnaire ratings and a measure of equipment usage.

Figure 11 represents the response distribution for an evaluation item dealing with changing waypoints in a navigation route. Nearly 60% of commanders agreed that it was easy to change waypoints and only 8.5% disagreed. Waypoints were changed the same way that waypoints were entered: an entry field was selected in the menu area and the location was then input from the map via the chosen method. For original entry the field was empty; when changing an entry, the field contained a location which was overwritten by subsequent input. Thus, if changing waypoints was easy, one can infer that entering waypoints was also easy.

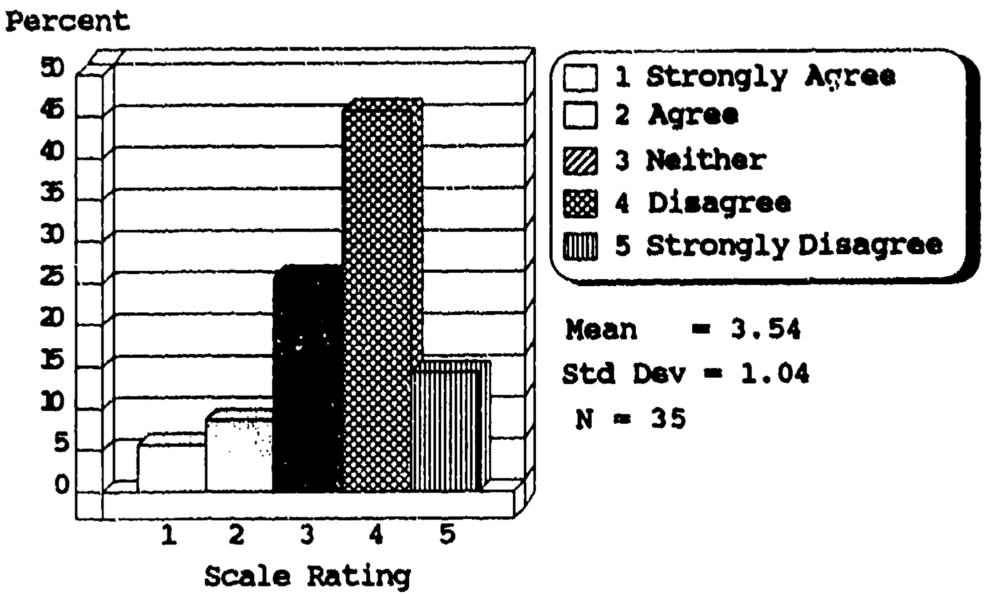

Figure 10. Vehicle commander response distribution: The Commander's Override Control contains too many functions.

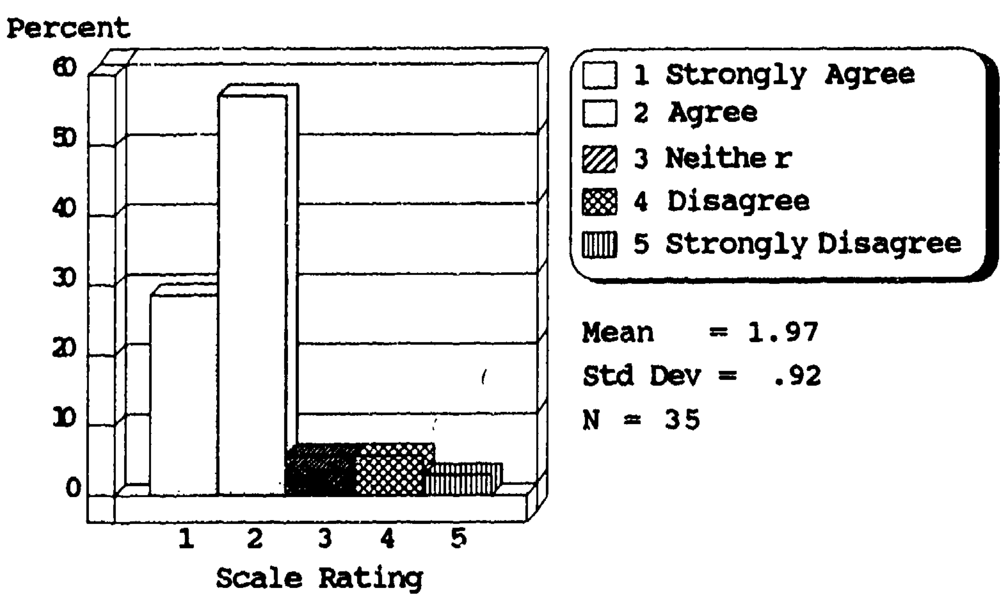

Figure 11. Vehicle commander response distribution: It was easy to change the waypoints.

Figure 12 represents the response distribution for an evaluation item dealing with the number of waypoints available in a route. Only 11% of commanders felt that they needed to input more then six waypoints, whereas 60% felt they did not, indicating that six waypoints were adequate for commanders' needs.

Currently, sending waypoints to the driver is not instrumented in the DCA and no automated data on the number of waypoints sent are available. Observations by RAs, debriefing comments, and responses to CCD and Driver Evaluation items provide evidence that this function was used regularly. The following discussion focuses on the Navigation function from the viewpoint of the driver.

Navigation and waypoint information was presented to the driver on the Driver's Display, which included the Steer-To Indicator with waypoint information (see Figure 4). As depicted in Figure 13, 94% of drivers disagreed that the Driver's Display was difficult to use. Further, 80% agreed that the Steer-To-Indicator gave them more confidence in moving from point to point (Figure 14) and 74% agreed that the Steer-To-Indicator would improve their performance (Figure 15). Twenty-eight percent of the drivers suggested that the Steer-To-Indicator could be improved by incorporating a cardinal direction indicator and providing an auditory signal for arrival at waypoints.

The Navigation function enabled vehicle commanders to assign more responsibility to drivers, thereby reducing workload for the vehicle commander. Ninety-seven percent of commanders agreed that they were able to give more responsibility to the driver. In a like vein, 94% of the drivers agreed that fewer communications were needed with vehicle commanders because of the Steer-To-Indicator, thereby reducing the driver's workload. This is consistent with Du Bois and Smith's (1989) finding that the ability to give the driver more responsibility increased that crewmember's role in land navigation.

In addition to using the Navigation function to direct their own tank, vehicle commanders could direct subordinates by sending navigation routes to them. Table 6 presents the means and standard deviations (SD) for the average **number of navigation routes activated** per phase, during the offensive and defensive scenarios. This measure is represented by the number of navigation routes received from another vehicle commander which were placed on the receiving commander's tactical map. No differences in duty position for this measure were significant. Albeit, the pattern of results is as one would expect: as one goes down the chain of command, more routes would be activated (if activated routes are directive).

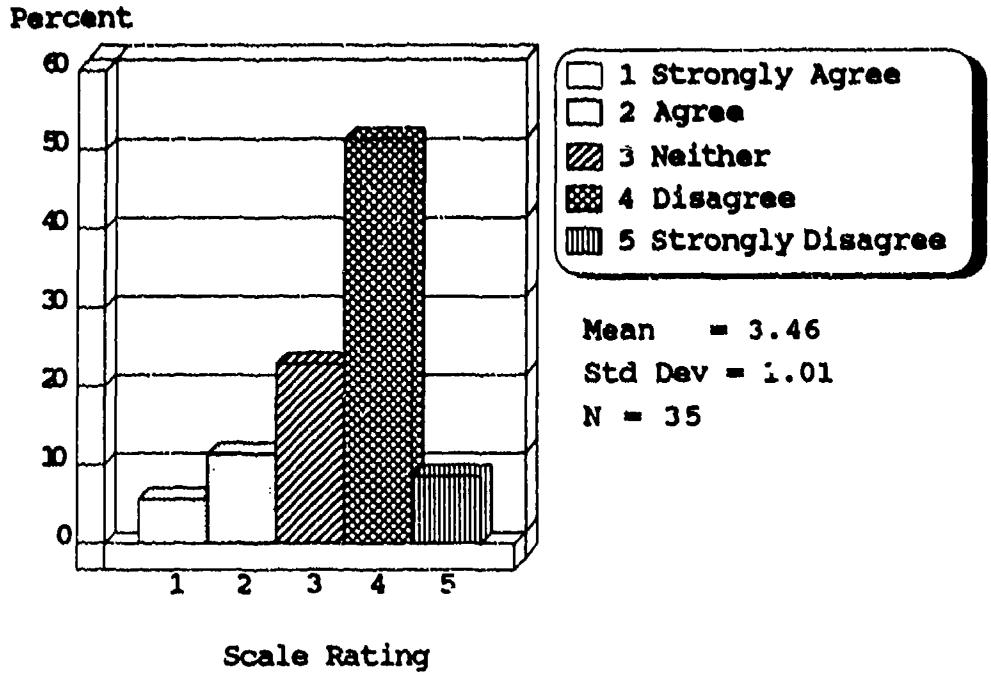

Figure 12. Vehicle Commander response distribution: I needed to input more than 6 waypoints at a time.

TCs activated routes from other vehicle commander's--most likely their own Plt Ldr--about once per phase. Since one objective was given at the start of each offensive phase and this objective did not change, one route would have been adequate. Likewise, only one destination was given during each defensive phase.

Finally, an element of POSNAV which aided navigation was the vehicle commander's own tank icon displayed on the Tactical Map. This icon indicated direction of the hull, gun tube, and CITV. Ninety-four percent of commanders agreed that this icon helped them keep track of their direction.

The Navigation function is a usable and useful component of the CCD. Vehicle commanders and drivers found the Navigation function to be easy to use and 37% of vehicle commanders indicated that POSNAV/Navigation were some of the features which most improved their performance. Drivers also felt that their performance would improve with this feature. Further, the ability to direct the driver and subordinates by transmitting waypoints and routes reduces the vehicle commander's workload.

Usefulness of the Tactical Map

The Tactical Map presented a color view of the terrain from an overhead perspective. Four map scales and several map features were available, all of which provided vehicle commanders the ability to tailor the map as they so desired. We

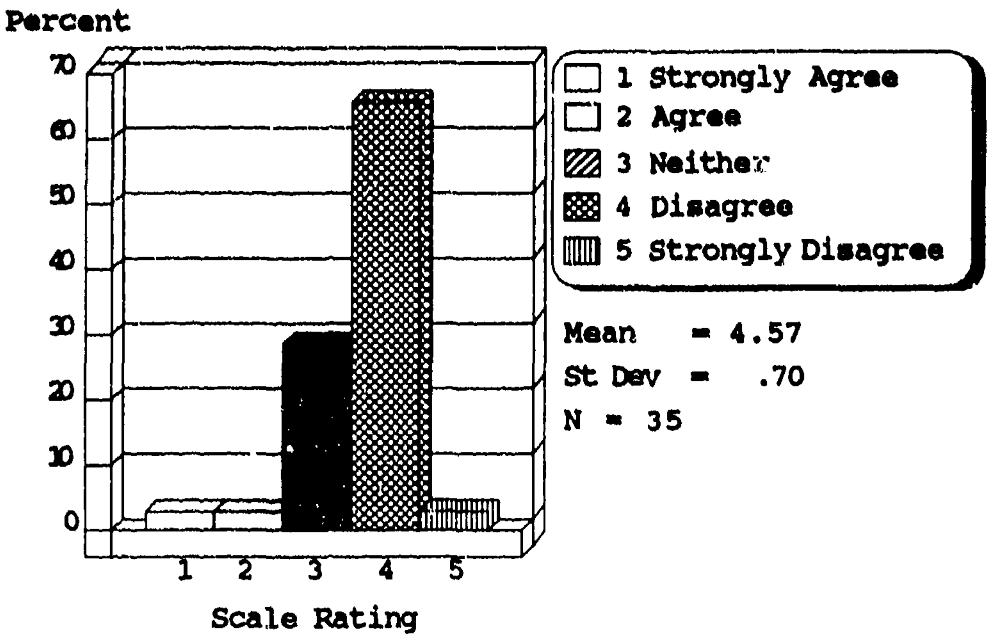

Figure 13. Driver response distribution: The Driver's Display was difficult to use.

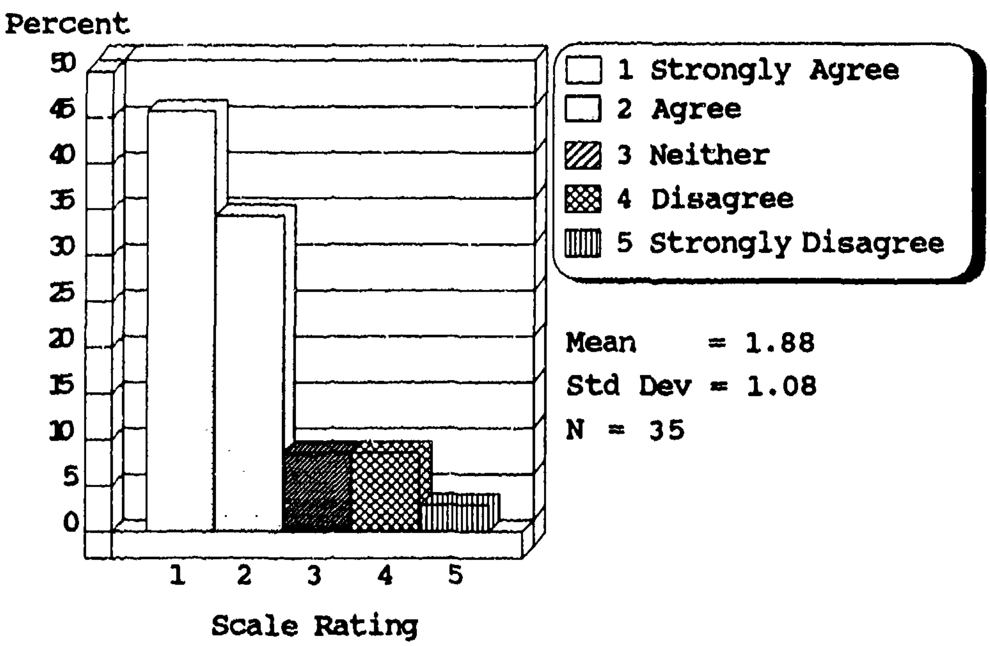

Figure 14: Driver response distribution: Having a Steer-To-Indicator gave me more confidence in moving from point to point.

investigated the usability and usefulness of the Tactical Map through a measure of equipment usage and questionnaire ratings.

The average percent of time in each map scale per phase represents the proportion of time during test scenarios that each map scale (1:25,000, 1:50,000, 1:125,000, 1:250.000) was in effect on the Tactical Map. Figure 16 represents the percent of time (average per phase) for the offensive scenario that each map scale was on the Tactical Map by duty position. Figure 17 represents this measure for the defensive scenario.

Prior to analysis the data in Figures 16 and 17 were adjusted for "Pre-data" values. Pre-data values were an artifact of the automated data instrumentation and reflect that period of time prior to the first change in equipment state. Instrumentation was event-based, meaning that no data were generated unless an event--such as changing the map scale or introducing a map feature--occurred. Therefore, the period of time before which the vehicle commander changed map scale or introduced a map feature (pre-data) reflected an unknown state. Percentages of time were thus computed using only known data states.

The preferred map scale was 1:50,000. This is to be expected, given that this is a standard military map scale and that participants had 1:50,000 paper terrain maps of the mission area. Based on an ANOVA investigating the effect of map scale and duty position, a main effect for scale was found in both scenarios: for the offensive scenario, $F_{3,100} = 42.28$, $p < .001$; for the defensive scenario, $F_{3,100} = 42.07$, $p < .001$.

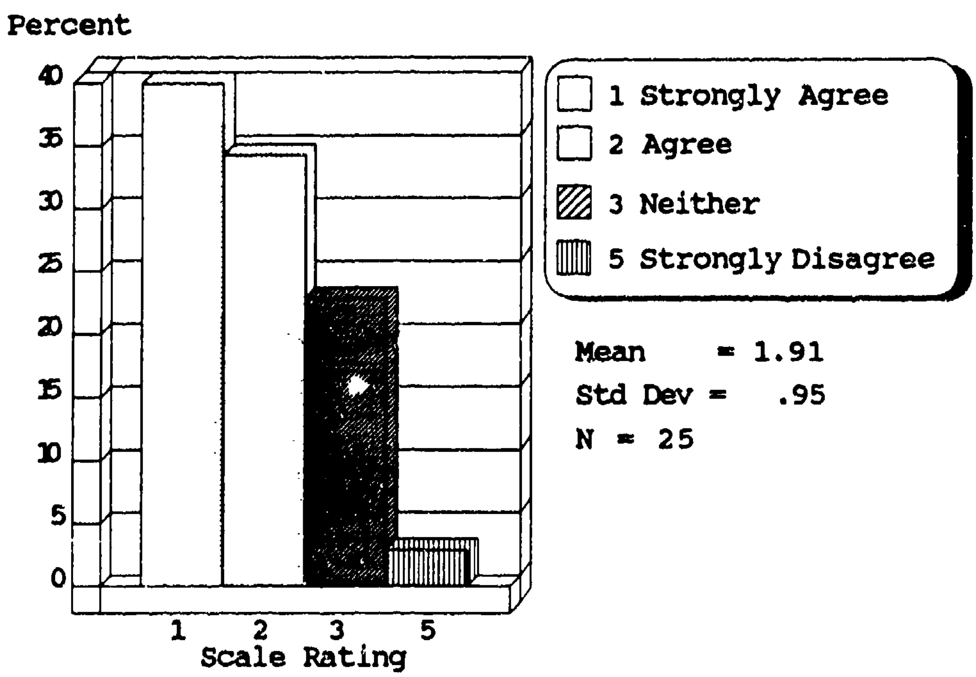

Figure 15. Driver response distribution: In a real tank, I feel the Steer-To-Indicator would improve my performance as a driver.

Table 6

Average Number of Navigation Routes Activated per Phase: Means and Standard Deviations (in parentheses)

Position	Offensive Scenario	Defensive Scenario
Co Cdr	.13 (.30) N=5	0 (0) N=5
Plt Ldr	.09 (.27) N=15	.18 (.31) N=15
TC	1.57 (1.12) N=15	1.10 (.51) N=15

Vehicle commanders did have occasion to use each scale during each phase, enabling them to gain perspective on the area--while using the higher scales--and to view their immediate area (1:25,000). While no main effect for position was found, the scale by position interaction was significant in the defensive scenario ($F_{6,100} = 2.34$, $p < .04$). Given that the four scale percentages sum to 100%, the mean for all duty positions is 25%. The duty position by input mode interaction, therefore, reflects the effect of duty position. Inspection of means (a table of means and standard deviations appears in Appendix D) indicates that the interaction results from the second most preferred scale. Co Cdrs', who were required to maintain control over a greater area, second preference was 1:125,000; Plt Ldrs' and TCs' second preference was 1:25,000.

Vehicle commanders displayed on their Tactical Map all map features (contour lines, grid lines, rivers, roads, and vegetation) about 92% of the time during each test scenario. This fact, combined with their ability to operate at the 1:50,000 scale indicates that the Tactical Map is as useful as a paper map. Clearly, displaying all features did not clutter the map, and the ability to change map scales and tailor map appearance provides a capability superior to a paper map. Differential use, based on echelon, was found for percent of time in each map scale. However, no implications for future design are suggested, as all map scales provide valuable unique viewing capabilities, necessary at all echelons.

Ninety-four percent of vehicle commanders considered the Tactical Map with POSNAV to be more helpful for navigating than a paper map. Further utility is gained from the Tactical Map when combined with digital overlays. All vehicle commanders agreed

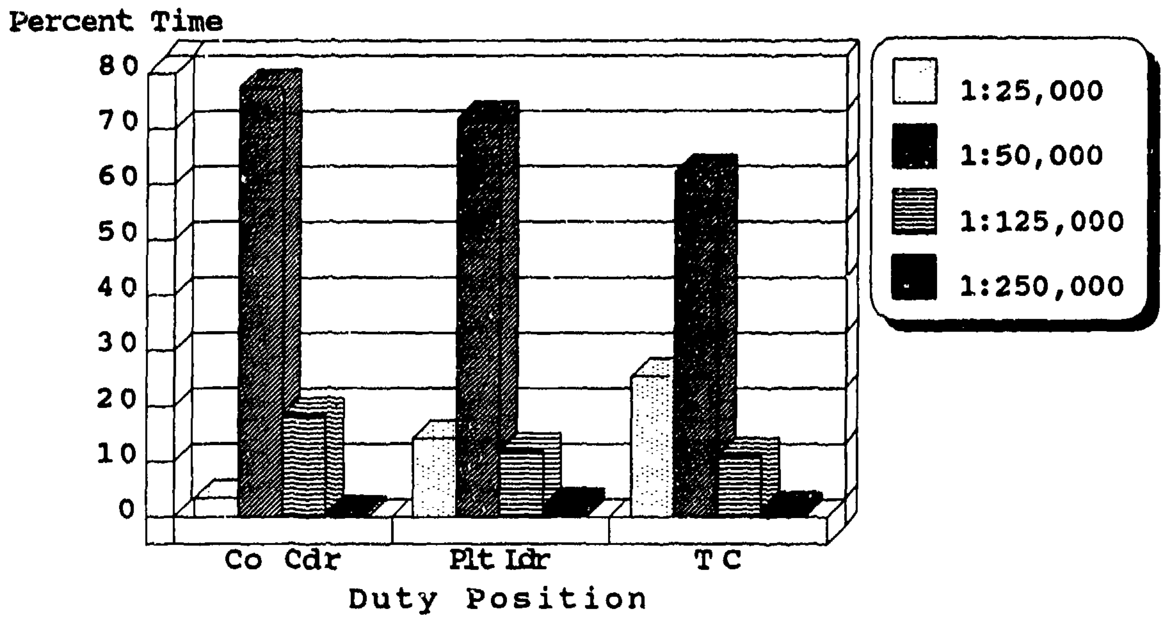

Figure 16. Average percent time per phase in each map scale, offensive scenario

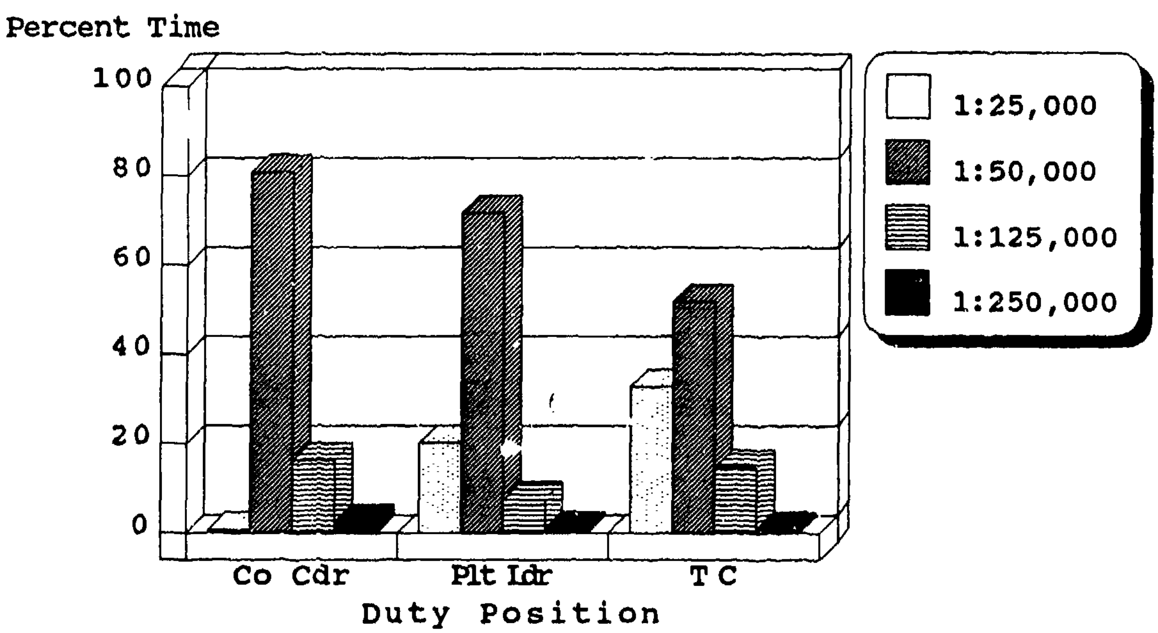

Figure 17. Average percent time per phase in each map scale, defensive scenario

that using overlays on the Tactical Map was easier than using grease pencils and lap maps; and 65% indicated that the Tactical Map and overlays were some of the CCD features which most improved their performance. RAs observed that vehicle commanders used their CCDs about 85% of the time and their lap maps only about 15%.

During debriefing sessions vehicle commanders suggested that the CCD could be improved by providing constant access to the map scale and scroll functions. Vehicle commanders reported frustration and wasted time when they were creating routes or reading reports and had to exit that function to go to the map and scroll to another area or change the scale of the map for viewing. Since this evaluation, this access has been provided with a dedicated function key.

Usability and Usefulness of CCD Reports

There are many aspects to CCD reports: creation, report icons, transmittal, and reception. In determining the usability and usefulness each of these aspects will be presented, in turn. We begin with an examination of the average **percent of grid inputs to reports by laser device**, per phase. This measure represents the proportion of the total number of grid location inputs to reports effected by CITV laser device. Those not effected by laser device were input from the Tactical Map either by Touch Screen or the Thumb Cursor. Table 7 presents the means and standard deviations for percent of grid inputs to reports by laser device during the offensive and defensive scenarios.

The data in Table 7 were analyzed in an ANOVA investigating the effect of input mode and duty position. A main effect for input mode was found in the offensive scenario, $F_{1,48} = 79.80$, $p < .001$. The input mode by duty position interaction was significant in both the offensive ($F_{2,48} = 3.48$, $p < .04$) and defensive ($F_{2,50} = 8.34$, $p < .001$) scenarios.

Co Cdrs input location grids via laser device much less frequently than their subordinates. These differences are indicative of the type of report originated by Co Cdrs. Co Cdrs tended to create more SITUATION and ADJUST FIRE reports (71% of all reports in the offensive scenario, 53% in the defensive scenario) and very few CONTACT and SPOT reports (3% in the offensive and 11.3% in the defensive). Conversely, of all reports originated by Plt Ldrs 29% (offensive) and 18% (defensive) were SITUATION and ADJUST FIRE reports and 38% (offensive) and 33% (defensive) were CONTACT and SPOT reports.

SITUATION and ADJUST FIRE reports were less likely to receive input via laser because of the location field referents (see Appendix E for an account of CCD report formats). The location field in a SITUATION report refers to friendly locations which are displayed on the Tactical Map and can easily be input to the report by touching or placing the Thumb Cursor on the POSNAV icon. ADJUST FIRE reports require location either by indicating a shift to a CALL FOR FIRE (CFF) location or by indicating a new location. The shift information does not require a map location and if the original CFF was posted to the Tactical Map, the new location can be provided from the map, orienting from the posted icon.

Table 7

Average Percent of Grid Inputs to Reports by Laser Device, per Phase: Means and Standard Deviations (in parentheses)

Position	**Offensive Scenario**	**Defensive Scenario**
Co Cdr	0 N=4	5.20 (7.56) N=4
Plt Ldr	23.44 (25.08) N=12	57.89 (30.47) N=12
TC	25.20 (26.53) N=11	45.95 (36.43) N=12

On the other hand, CONTACT and SPOT reports aré those reports which are most likely to receive locations via laser input. These reports require locations for enemy vehicles which are not provided by POSNAV. Thus, lasing to these vehicles with the CITV provides the most immediate and accurate means of inputting locations to CCD reports.

Based on usage patterns, the ability to input report locations using the CITV is a useful feature of the CCD; nearly 50% of report locations were input using the laser in the defensive scenario by Plt Ldrs and TCs and about half as frequently during the offensive scenario. The differential use of this feature by duty positions is thought to be based on report type, but grid input by laser data were not available by report type to confirm this.

<u>Automatic posting of report icons</u>. This feature provides vehicle commanders with redundant information about the arrival of reports (along with the lighting of the Receive Button and beeps in the headset) as well as reported locations. This is especially useful during battle, when immediate access to information is important.

A measure of equipment usage related to the CCD report function is the **median number of report icons on the Tactical Map** at any given time during a phase (inspection of distribution statistics indicated a slightly skewed distribution, thus median provided a better measure of central tendency). These icons include temporary icons representing reports in the Receive Queue, automatically-posted and permanent icons representing INTELLIGENCE and CONTACT reports, and report icons posted by the vehicle commander. Table 8 presents the means and standard deviations for this measure during the offensive and defensive scenarios. Based on ANOVA, there was an effect for duty position during the offensive scenario ($F_{2,31} = 6.21$, $p < .005$). During this scenario TCs had about a third as many icons on their map as did Co Cdrs and Plt Ldrs. TCs had about half as many icons on their map during the defensive scenario, but the effect of duty position was not significant in this scenario.

Table 8

Median Number of Icons on Tactical Map, Average per Phase: Means and Standard Deviations (in parentheses)

Position	Offensive Scenario	Defensive Scenario
Co Cdr	21.13 (12.06) N=5	19.70 (8.80) N=5
Plt Ldr	27.48 (21.20) N=15	19.36 (18.95) N=15
TC	7.57 (5.60) N=14	10.08 (5.94) N=15

The differences between TCs and other vehicle commanders may have been due to the fact that TCs receive reports on only their platoon net, while Plt Ldrs receive reports on both the platoon and company net. Likewise, Co Cdrs receive reports on both the company and battalion net--therefore there was a greater chance for report-based icons to have been on the map. On the other hand, it could mean that TCs deleted more reports and/or icons than other vehicle commanders.

Of those report icons in Table 8, between one and two were posted by the vehicle commander during each scenario. This low number is probably not unusual in light of the fact that it was not necessary to post INTELLIGENCE and CONTACT reports. Further, the number of existing icons on the map at any given time may have precluded further postings.

When asked if the CCD presented too much information, slightly more vehicle commanders disagreed (42.8%) than agreed (40%). Ratings in agreement may have been a reflection, at least in part, of the number of report icons displayed on the Tactical

Map. Figure 18 represents the response distribution for this question.

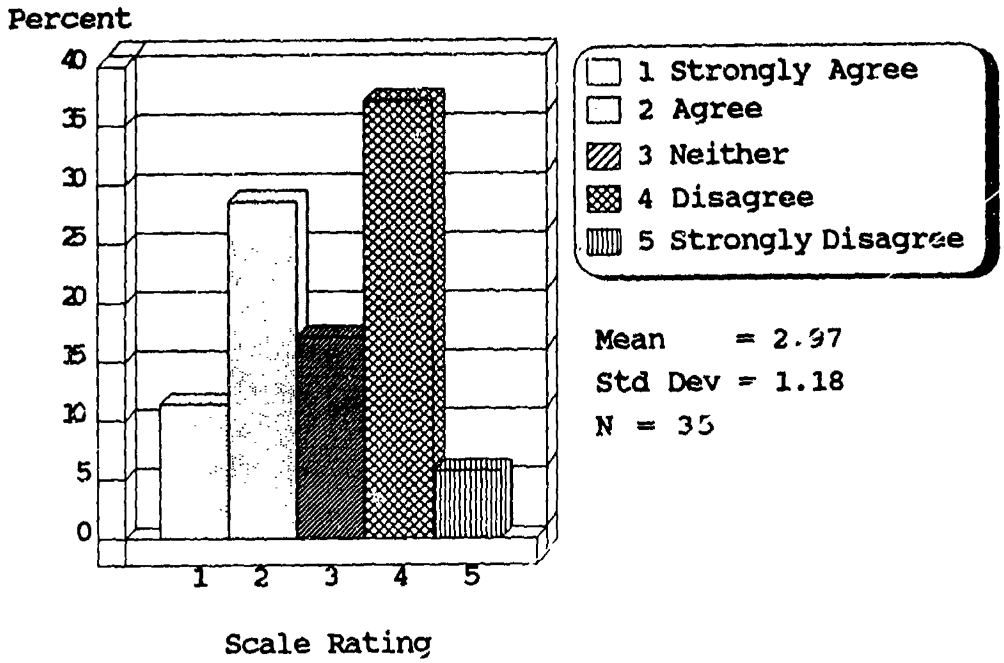

Figure 18. Vehicle commander response distribution: The CCD often presented too much information.

During debriefing sessions, vehicle commanders stressed the need for improvements to report icons. Currently, generic icons (similar to an asterisk) denote SHELL, SITUATION, and ADJUST FIRE reports, and obstacles from INTELLIGENCE reports, making it hard to discern what the icon represents. CONTACT, CFF, and SPOT report icons are based on the type of vehicle identified and thus their meaning is clearer, but the type of report cannot be distinguished. Only the NBC report has unique icons (unfortunately, these icons do not conform to standard military symbology).

The large number of report icons on the Tactical Map at any given time, coupled with an interpretability problem, compromises the usability and usefulness of the automatic posting feature. Improvements to report icons should increase usability and usefulness. The number of icons appearing on the map can be reduced by improvements to the report function itself, such as combining similar reports into a single report.

Along with an improved symbol library, further means of improving the usability of report icons are currently under investigation. For example, direct viewing of reports from icons. Currently, if an icon is touched (or the cursor is placed on it) and the report is in the [open] Receive Queue the report becomes highlighted. If the report is not in the queue, a message indicates in which old file the report can be found.

Total number of reports originated. This measure represents the average number of reports created and transmitted per phase, collapsed across all report types. Vehicle commanders transmitted an average of 5.08 (Std Dev = 3.64) digital reports per phase during the offensive scenario and 6.55 (Std Dev = 4.14) digital reports per phase during the defensive scenario. To investigate differential use of the report function, duty position was tested in ANOVA. No differences were found, the average number of reports originated per phase by individual duty positions ranged from 4.94 to 5.92 in the offensive scenario and 5.79 to 7.24 in the defensive.

The number of reports originated during each phase was consistent with the number of events in the scenario which might prompt reports. During the offensive scenario there was one enemy engagement per phase; during the defensive scenario there were one (first and third phase) or two (second phase). An engagement could be expected to produce CONTACT and SPOT reports from each vehicle which had killed enemy vehicles, some number of SHELL reports, CFFs, and ADJUST FIRE reports, and a SITUATION report from each Plt Ldr and the Co Cdr. For this evaluation an NBC report was scripted during the first phase of each scenario (and always originated by one of the Plt Ldrs in command of a tethered platoon).

However, there was no limit to which vehicle commanders must adhere for the number of reports to be generated. That is, while only one CONTACT report per engagement might have been necessary, any number may have been generated. Likewise, a single SPOT report may have been generated at the end of an engagement or after each enemy vehicle was destroyed.

Other factors mitigate the number of reports sent. For example, if a company was effective in destroying the enemy early in an engagement, fewer CFFs and ADJUST FIREs would have been necessary. Further, more accurate CFFs would reduce the number of ADJUST FIRES. Finally, vehicle commanders had the option of sending their reports over the radio, and 20% of all reports were sent over the radio. In particular, CFFs were more likely to be sent over the radio because pre-planned fires and concentration of fires could not be called with digital CFFs. Therefore, while the number of reports originated looks rather low, they probably represent a sufficient number given the structure of the scenarios. The additional engagement during the second defensive phase may account for the higher number of reports originated during that scenario.

Also bearing on the number of reports originated may be the difficulty that some vehicle commanders had creating reports. Reports were created by providing location information from the Tactical Map or with the CITV laser and selecting from options for other input. All entries were prompted by highlighted fields. While 88% of vehicle commanders agreed that the highlighting was useful, only 34% agreed that creating reports was easy. Figure 19 represents the response distribution for this latter item.

Most reports which were created were transmitted. Those reports not transmitted would have been cancelled, deleted, or simply left on the CCD with no further action taken (although that would have precluded preparing any further reports of that type). There was little wasted effort in the preparation of reports. In the offensive scenario 85.02% (Std Dev = 16.58) of prepared reports were transmitted, while 85.90% (Std Dev = 19.13) were transmitted in the defensive scenario.

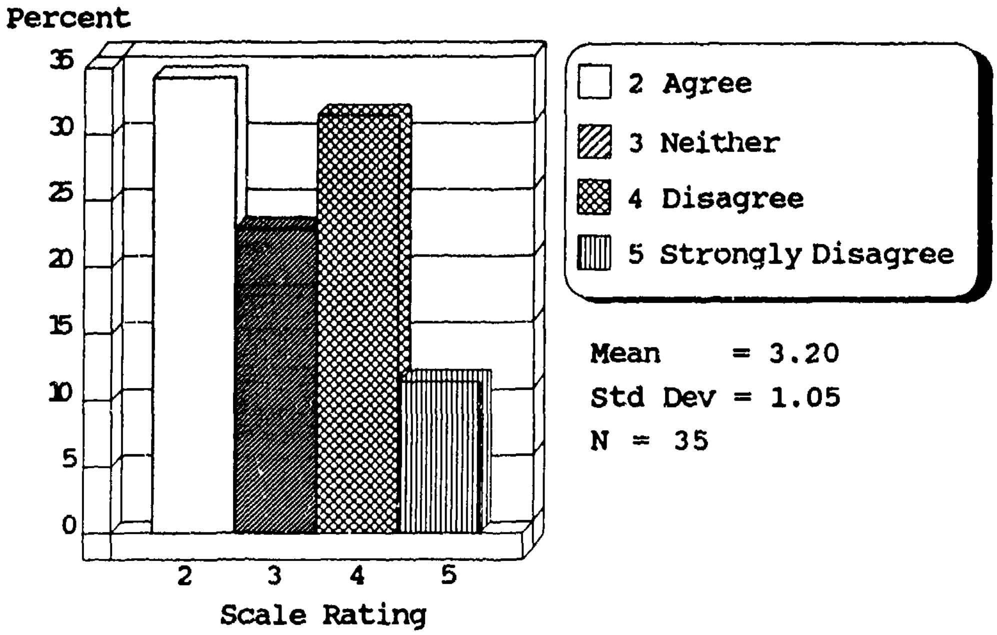

Figure 19. Vehicle commander response distribution: It was easy to create reports on the CCD.

It should be noted that the data for the number of reports originated is based the first time a report was transmitted. This qualification was necessary because subsequent transmittals of the same reports become problematic in their interpretation. Given that all vehicle commanders on the transmittal net received a copy of the transmitted report, it is unclear what purpose a second or third transmittal served. During debriefings, vehicle commanders reported taking the "safest" approach in transmitting reports: if they were at all uncertain that the report had been received or retrieved, they re-transmitted. Unfortunately, this conservative approach resulted in sizable Receive Queues containing duplicate reports (multiple copies of the same report) and concomitant unfavorable perceptions pertaining to the management of those queues, as indicated by the response distributions in Figures 20 and 21. Fifty-seven percent of vehicle commanders agreed that it was difficult to manage the reports they received over the CCD, and 71% indicated that they did not have enough time to read all of their CCD reports. When asked what features of the CCD most degraded their performance, 20% of vehicle commanders answered that it was the large number of reports they had to review.

Accounts of difficulty in creating CCD reports and in dealing with the number of reports received indicate that a disproportionate amount of effort is required to successfully use the report function (as it applies to these areas). The current implementation also promotes errors in transmittal decisions. That is, a lack of clear feedback that a transmitted report has been received or retrieved leads to re-transmittals, which contributes to lengthy Receive Queues. This latter point will be the subject of further discussion as additional results are presented.

Percent of reports retrieved from Receive Queue. This measure represents the average proportion of reports which were retrieved, or opened, from the Receive Queue, per phase. Reports not retrieved from the Receive Queue were retrieved from an old file. Reports which had not been opened or deleted moved from the Receive Queue into the appropriate old file after about five minutes. Reports which had been opened from the Receive Queue subsequently moved into an old file unless deleted.

The majority of reports were retrieved from the Receive Queue: 96.82% (Std Dev = 4.55) in the offensive scenario and 95.50% (Std Dev = 8.69) in the defensive scenario. Vehicle commanders tended to leave their Receive Queue displayed so that they could readily retrieve the incoming reports (as reported by research assistants).

The Receive Queue provides the most immediate and useful means of accessing incoming reports. The low percentage of reports retrieved from old files may be a reflection of the many messages being received--vehicle commanders simply did not have time to go to an old file. Improvements to the report function should result in a greater ability to assess the utility of old files.

Reviewing reports from old files may be more useful in providing an historical record of a mission, when more in-depth reporting and after-action assessments might be required. Test scenarios did not support an investigation of this as there was no requirement for vehicle commanders to provide after-action accounts of a mission.

Percent of all reports retrieved. This measure represents the average proportion of all reports which were retrieved, per phase. Duty position has been further classified to separate Plt Ldrs into two groups: manned Plt Ldrs and tethered Plt Ldrs. Manned Plt Ldrs commanded the second platoon which was entirely manned. Tethered Plt Ldrs commanded the first and third

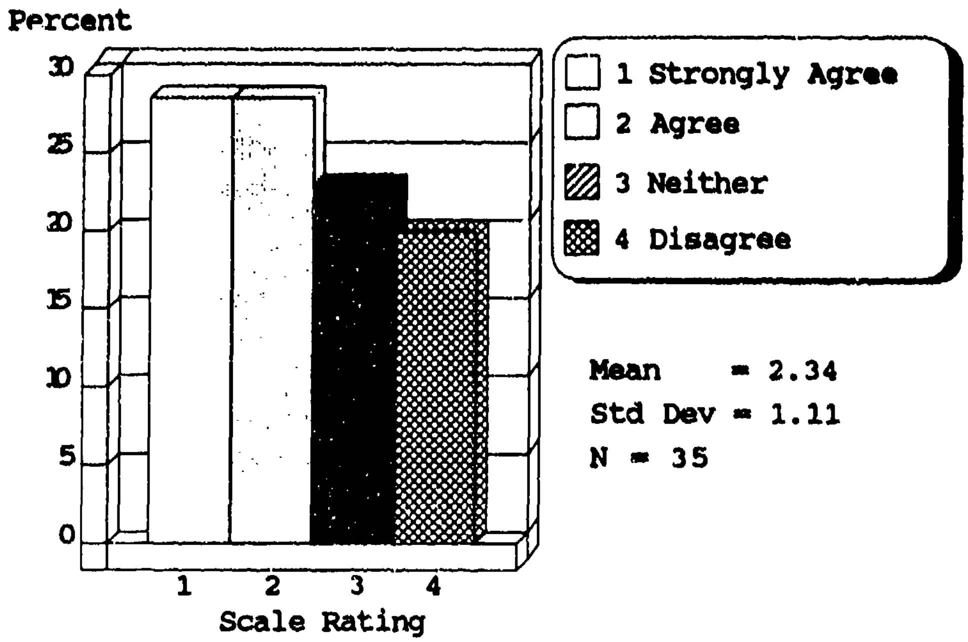

Figure 20. Vehicle commander response distribution: It was difficult to manage all of the reports sent to me over the CCD.

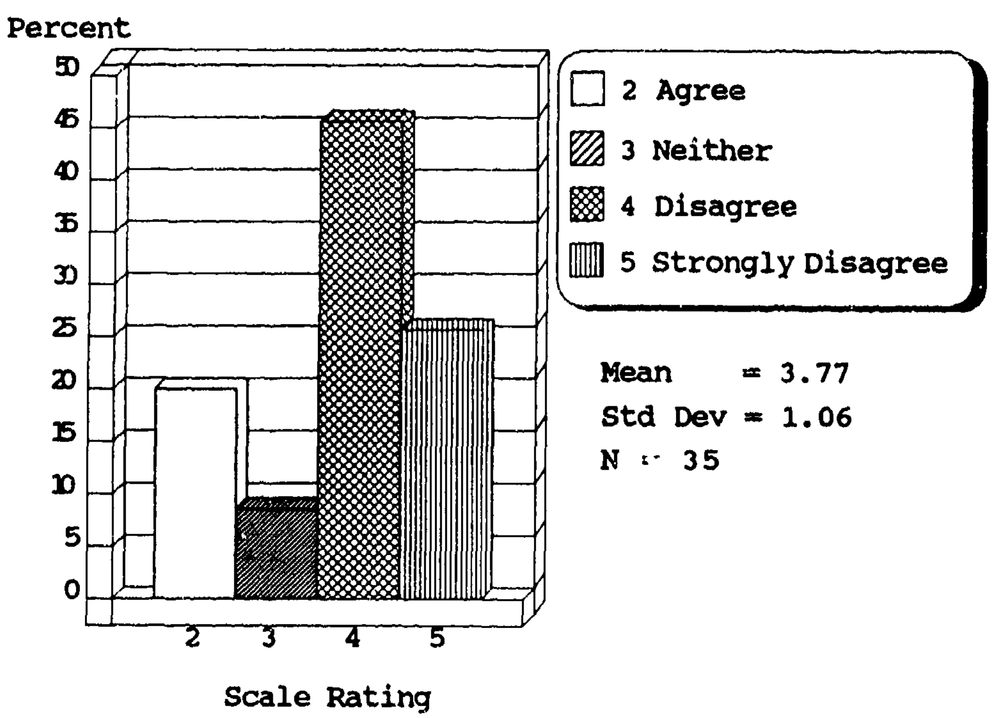

Figure 21. Vehicle commander response distribution: I had enough time to read all of my messages.

platoons, which were comprised of tethered SAFOR vehicles, except for the Plt Ldr himself. SAFOR vehicles were capable of transmitting only SPOT, CONTACT, and SHELL reports, but these reports were transmitted on a frequent basis. In addition to higher reporting rates, SAFOR reports were more immediate and accurate (SAFOR reporting parameters, including type, immediacy of reports, and reporting rates are currently under revision). Given these differences, a separate analysis treatment for tethered Plt Ldrs is appropriate.

Table 9 presents the means and standard deviations for the average percent of reports retrieved during each phase of the offensive and defensive scenarios. Differences in retrieval rates by duty position were investigated in an ANOVA. This investigation was conducted to determine if level of responsibility would impact retrieval rates. The results indicate that it does. An effect of duty position was found in both the offensive ($F_{3,30}$ = 3.55, $p < .03$) and defensive ($F_{3,31}$ = 4.73, $p < .001$) scenarios.

Table 9

Average Percent of all Reports Retrieved per Phase: Means and Standard Deviations (in parentheses)

Position	Offensive Scenario	Defensive Scenario
Co Cdr	57.06 (19.11) N=5	56.44 (16.11) N=5
Manned Plt Ldr	31.14 (9.57) N=5	26.28 (7.85) N=5
Tethered Plt Ldr	26.90 (13.13) N=10	17.74 (9.77) N=10
TC	30.76 (21.57) N=15	34.35 (25.83) N=14

While the means for tethered Plt Ldrs are somewhat less than those for the manned Plt Ldrs, the effect of duty position, based on orthogonal contrasts, is attributable to the difference between Co Cdrs and all other duty positions in both the offensive scenario ($F_{1,30}$ = 9.94, $p < .004$) and defensive scenario ($F_{1,31}$ = 10.30, $p < .003$).

Co Cdrs retrieved about twice as many reports in both scenarios, which was consistent with their level of responsibility. The observed differences between tethered and manned Plt Ldrs were not significant. This latter point indicates that tethered Plt Ldrs were as willing as their counterparts to assume their simulation role and treat the reporting performance of their tethered platoon members as they would manned members.

The percentages in Table 9 are not particularly high, but are consistent with the reported problems in managing the volume of CCD messages. However, the data in Table 9 are themselves problematic. The data were not adjusted to reflect retrievals of unique reports (i.e., first sends). Thus, vehicle commanders may indeed have retrieved a greater percentage of unique reports (or may have repeatedly retrieved the same report).

Lengthy Receive Queues and multiple copies of reports may not have been the only factors influencing retrieval rates. Perhaps retrieval was not always necessary. The arrival of a new report was signalled by beep(s) in the headset and a flashing icon placed on the map in the appropriate location. This information, coupled with the type of report and originator (displayed in the Receive Queue) may have sometimes provided vehicle commanders with sufficient information.

Percent of reports relayed by report type. This measure represents the average proportion of reports received per phase from other vehicle commanders which were subsequently transmitted upward or downward and is computed both by report type and averaged across all report types. For this measure duty position is characterized by Co Cdrs, tethered Plt Ldrs, and manned Plt Ldrs. It was expected that tethered Plt Ldrs would do less downward relaying than manned Plt Ldrs.

TCs were not included in this analysis because they receive only downward-going reports and therefore had no need to relay reports. There were a few reports relayed by TCs (about eight or nine over the entire evaluation); however these errors were not included in the analysis of relays.

Just as it was necessary to qualify the number of reports transmitted, it was also necessary to restrict this measure to the first time a vehicle commander relayed a given report. A given report should only have been relayed on a net different from the one on which it was received (because everyone with access to the sending net would have received it). Since each vehicle commander had access to no more than two nets it would never have been necessary to relay the same report more than once. There were several repeated, or redundant, actions on reports (by the same participant or on the same net). Inspection of the net traffic might find a report sent on the battalion and company nets and then relayed two or three times on the platoon and company nets. It was not possible to determine what repeated actions on a given report meant--were they intentional, errors in selection, errors in decision, superstitious behavior?

Each report had a message identifier that included the originator's identification, the report type, and the time it arrived in the Receive Queue. Thus, each time the same report was relayed, it would appear to be a new report because it had a new arrival time. Given this information, a vehicle commander did not know if he had already read or relayed a message. If he was unsure about the status of a report--whether he had sent it, or whether it had been received--he resent or relayed the report, contributing multiple report copies to increasing Receive Queues.

Table 10 presents the means and standard deviations for the percent of reports relayed during the offensive scenario. Table 11 presents these data for the defensive scenario. Not included in these tables were mean values for the percent of AMMUNITION reports relayed; these values were zero for all duty positions. Also not included, for tethered Plt Ldrs, were values for those reports which SAFOR could not generate.

Initial data reduction of the percent of total reports relayed by tethered Plt Ldrs did not exclude those report types which SAFOR could not generate, resulting in a misrepresentation of this measure. Therefore, the value for percent of total reports relayed in Tables 10 and 11 was computed by averaging non-zero means for individual report types.

Relay rate was investigated for an effect of duty position, to determine differential use of the reporting function. Based on ANOVA, relay rate differed by duty position for percent of total reports relayed ($F_{2,17} = 16.55$, $p < .001$). Orthogonal contrasts showed that this difference was based on the difference between Co Cdrs and Plt Ldrs ($F_{1,17} = 19.82$, $p < .001$).

In the offensive scenario, an effect for duty position was found for individual report types as follows: CONTACT ($F_{2,17} = 4.33$, $p < .03$), CFF ($F_{2,13} = 43.75$, $p < .001$), ADJUST FIRE ($F_{2,17} = 16.35$, $p < .001$), SPOT report ($F_{2,17} = 6.72$, $p < .007$), and INTELLIGENCE reports ($F_{2,17} = 4.39$, $p < .03$).

The reports in Tables 10 and 11 are of two general types, those generally relayed upward and those generally relayed downward. The downward going reports (FRAGOs and INTELLIGENCE reports) contained new information which vehicle commanders could not independently obtain (as they could, for example, in a CONTACT or SHELL report). FRAGOs contained a change of mission and INTELLIGENCE reports contained information about enemy activity and obstacles in or near their sector. Each was vital for the Co Cdr to get to his Plt Ldrs and each had the highest percent relays.

At the start of phases two and three of each scenario, one FRAGO was issued by test support personnel (per phase values for FRAGOs were based on these two phases) and it was imperative that all vehicle commanders receive it in order to execute the mission. FRAGOs required relay downward from echelon to echelon. Thus, relay rates lower than 100% represented a serious problem.

Table 10

Average Percent of Reports Relayed per Phase of the Offensive Scenario: Means and Standard Deviations (in parentheses)

Report Type	Co Cdr	Manned Plt Ldr	Tethered Plt Ldr
CONTACT	51.93 (23.57) N=5	24.18 (13.82) N=5	25.86 (15.83) N=10
SHELL	26.81 (12.25) N=5	23.28 (18.40 N=5	10.95 (10.74) N=10
CFF	73.61 (22.74) N=4	68.12 (21.92) N=4	---
ADJUST FIRE	75.00 (35.36) N=5	44.33 (37.00) N=5	---
SPOT	51.78 (27.60) N=5	11.31 (12.23) N=5	19.87 (16.29) N=10
SITUATION	14.77 (24.77) N=5	3.94 (5.40) N=5	---
FRAGO	100.00 (0) N=5	78.33[a] (21.73) N=5	72.50 (41.48) N=10
INTELLIGENCE	93.33 (9.13) N=5	84.44 (12.04) N=5	47.78 (41.92) N=10
NBC	43.33 (9.13) N=5	45.71 (36.63) N=5	---
Total (Averaged over all report types)	56.89 (12.93) N=5	38.58 (7.77) N=5	35.39[b] N=10

a. All participants received at least one FRAGO per phase. See text for discussion of multiple FRAGOs.
b. Value computed from non-zero means, not individual values.

Because of this, the raw data were inspected. That inspection found that 1) all FRAGOs were relayed at least once on all nets, and 2) the total number of times a FRAGO was relayed ranged fromone to five times. Thus, FRAGOs were sometimes relayed more frequently than was necessary, but all vehicle commanders did execute the mission with the requisite information (in both offensive and defensive scenarios). However, relay rates in Tables 10 and 11 were computed using a numerator that included all report receptions, hence, multiple receptions of the same FRAGO, and resulted in percentages less than 100%

Most upward going reports contained information to which all vehicle commanders potentially had access and which might, therefore, require less relaying. For example, if a Plt Ldr had transmitted a CONTACT, SHELL, CFF, or ADJUST FIRE and received a similar one from his subordinates, he had no need to relay it. In addition, a Plt Ldr received reports from three TCs; if the reports contained similar information he would not need to relay all of them. Thus, upward going reports were relayed at lower rates.

The report type with the lowest percent relay was the SITUATION report. These reports were integrated at each level (platoon and company) and generally did not lend themselves to relay, unless they contained information which accurately reflected unit status.

Differences in relay rates between manned and tethered platoons were evident in SHELL, SPOT, and CONTACT reports. These rates do not follow a pattern based on immediacy and greater accuracy/volume of SAFOR reports. An interpretation of the pattern would not be prudent, given that the data include duplicate reports and direction of relay can only be inferred.

For the defensive scenario, the effect for duty position was significant for percent of total reports relayed ($F_{2,17} = 21.66$, $p < .001$). Orthogonal contrasts showed that this effect was based on the difference between Co Cdrs and Plt Ldrs ($F_{1,17} = 36.47$, $p < .001$).

Specific report types for which the effect of duty position was significant were as follows: CONTACT ($F_{2,17} = 6.28$, $p < .01$), CFF ($F_{2,16} = 31.50$, $p < .001$), ADJUST FIRE ($F_{2,17} = 9.59$, $p < .001$), and SPOT report ($F_{2,17} = 5.98$, $p < .01$).

The same pattern of results is evident for the defensive scenario as was for the offensive scenario. Downward going reports were relayed at the highest percentages and Co Cdrs were the most diligent at disseminating the information. Upward going reports were relayed less frequently and again, Co Cdrs relay a greater percentage of reports. Given that Co Cdrs originate the same number of reports as other duty positions, the greater number of relays is not merely a reflection of greater volume. Rather, Co Cdrs appear to benefit more from the ability to review pertinent battlefield information and convey it to superiors.

Table 11

Average Percent of Reports Relayed per Phase of the Defensive Scenario: Means and Standard Deviations (in parentheses)

Report Type	Co Cdr	Manned Plt Ldr	Tethered Plt Ldr
CONTACT	50.93 (17.96) N=5	25.50 (18.56) N=5	18.20 (15.73) N=10
SHELL	40.48 (28.64) N=5	20.79 (13.06) N=5	15.02 (14.48) N=10
CFF	66.02 (20.94) N=5	14.70 (18.12) N=5	---
ADJUST FIRE	46.71 (40.62) N=5	5.38 (6.84) N=5	---
SPOT	40.66 (27.33) N=5	14.88 (13.00) N=5	9.90 (10.35) N=10
SITUATION	0 N=4	0 N=5	---
FRAGO	95.00 (11.18) N=5	62.78[a] (25.95) N=5	50.83 (47.70) N=10
INTELLIGENCE	83.33 (16.67) N=5	63.22 (29.25) N=5	44.44 (43.27) N=10
NBC	67.50 (39.48) N=5	35.00 (47.26) N=5	---
Total (Averaged over all report types)	52.49 (8.21) N=5	24.70 (7.63) N=5	27.68[b] N=10

a. All participants received at least one FRAGO per phase. See text for discussion of multiple FRAGOs.
b. Value computed from non-zero means, not individual values.

Comparison of unique relays to total relays. This ad hoc comparison, performed after reviewing the preceding report function data, was performed to gain insight into the number of duplicate reports which were populating Receive Queues. It compares the average number of unique, or first, relays per phase with the average total number of, or all, relays per phase. As with the previous measure, duty position is characterized by Co Cdrs, tethered Plt Ldrs, and manned Plt Ldrs.

Table 12 presents the means and standard deviations for the number of unique relays and the total number of relays during the offensive scenario. The table also provides the percent increase of all relays over unique relays. That is, the percentage of relayed reports which were duplicates. The same data are presented for the defensive scenario in Table 13.

Table 12

Comparison of Unique Relays to Total Relays (Average per Phase) during the Offensive Scenario: Means and Standard Deviations (in parentheses)

Duty Position	Unique	Total	% Increase
Co Cdr	5.27	14.40	173
(N=5)	(1.04)	(1.44)	
Manned Plt Ldr	3.67	10.13	176
(N=5)	(1.18)	(3.53)	
Tethered Plt Ldr	5.88	9.10	55
(N=10)	(4.11)	(6.39)	

The increase in reports as a result of redundant relays ranges from 55% to 176% over both test scenarios. If these percentages were at all representative of vehicle commanders' approach to message traffic (and based on inspection of raw data and debriefing comments, it is safe to assume so) it is evident why the percentage of retrieved reports was low and how Receive Queues became unmanageable.

The proliferation of duplicate reports is primarily a result of inadequate feedback. Vehicle commanders, while given feedback that a report had been sent, received no indication whether it had been received or retrieved. Further, they did not have information concerning previous actions they may have taken on a given report. Thus, they may have repeatedly sent or relayed reports because they were unsure if they had already done so or if the reportt had been received. To compound the problem, if a vehicle commander called to verify receipt, and the recipient had received multiple copies of the report, that recipient would have difficulty in discerning to which report the caller was referring, because each copy of the report would differ only by the time sent.

A contributing factor to redundant report actions may have been a lack of understanding, on the part of vehicle commanders, of the net structure and the result of redundant report actions. Prior to testing, participants received two and one half days of training. Training was well structured and monitored. However, there was a great deal of information conveyed in that period and the emphasis was on hands-on equipment training and scenario execution. Regrettably, there may not have been adequate time to devote to more conceptual aspects and finer details of the system.

Table 13

Comparison of Unique Relays to Total Relays (Average per Phase) during the Offensive Scenario: Means and Standard Deviations (in parentheses)

Duty Position	Unique	Total	% Increase
Co Cdr (N=5)	9.60 (4.31)	17.87 (6.65)	85
Manned Plt Ldr (N=5)	4.53 (4.06)	11.87 (6.67)	176
Tethered Plt Ldr (N=10)	4.30 (2.75)	6.68 (4.27)	55

CCD Report Summary

The CCD report function is an important part of the CCD. The ability to rapidly disseminate information via digital burst is a critical component of automated C^3. The usefulness of CCD reports is demonstrated by the relatively low number of reports transmitted over radio, indicating that CCD reports fit the needs of vehicle commanders. Further, the moderate number of reports which were necessary during a given phase indicates the efficiency of the digital medium. Twenty-three percent of vehicle commanders identified reports as the CCD feature which most improved their performance.

However, the CCD report function data indicate problems with usability. The primary problem centered around being able to accommodate the large numbers of reports received. Given the moderate number of reports originated during a phase, the reason for lengthy Receive Queues must lie elsewhere. Inspection of automated data and comments made in debriefings indicated that the problem lie with redundant report actions. These redundant report actions are, at least in part, due to inadequate feedback on report status.

Problems with the usability of the report feature indicate a need for improvement. Current improvements are underway and include additional feedback on report actions (symbols indicating whether a report has or has not been opened, sent, or relayed) and elimination of duplicate reports in the Receive Queue.

Further improvements are under study, such as receipt acknowledgement, and aggregation of similar reports into summary reports.

Additional problems with reports were highlighted in questionnaire items, where vehicle commanders indicated that they had trouble creating reports and that reports were too lengthy to prepare (see Appendix C for rating distributions and descriptive statistics).

Methods for streamlining report formats should be investigated, focusing on elimination or reduction of multi-paged reports. These reports increase preparation time not only because of the number of input fields, but also because they increase computer response time. Vehicle commanders reported problems in both of these areas.

CCD Summary

Overall, the CCD was viewed favorably by vehicle commanders. The majority of questionnaire items reflect positive ratings and automated data indicate that it was successfully used throughout the test scenarios. Eighty percent of vehicle commanders felt the CCD would improve their "real world" performance as a tank commander, and seventy-four percent of drivers felt the navigation equipment would improve their performance.

As in previous evaluations, the Tactical Map and POSNAV were the most well accepted features of the CCD, with little or no problems encountered. The CCD report function was also considered a critical aspect of the CCD. However, problems with usability were identified. These problems centered around inadequate feedback on report status and resulting redundant report actions.

The CCD data analyzed by duty position produced few differences that support tailoring CCD functions to echelon requirements. Those that were found were primarily in the report functions. Co Cdrs, while not originating more reports, did relay more reports, and input fewer locations to reports via the CITV laser. The latter finding is thought to be based on report type. Type of report originated by echelon may be a fruitful area of investigation as higher echelons are included in evaluations.

The CITV

The following presents results associated with the usability and usefulness of the CITV. Automated measures and questionnaire responses addressing general operating characteristics and the Designate and Target Stack functions are presented and discussed.

Percent of time in each operating mode. This measure is represented by the average percent of time per phase each CITV operating mode--Manual Search, Autoscan, GLOS, GPS--was in effect. Manual Search and Autoscan provided the vehicle commander independent surveillance modes which he could, respectively, control manually with the control handle, or automatically sweep back and forth between specified sectors. A third surveillance mode was GLOS, which slaved the CITV line of sight to the main gun and provided the commander with a view overlooking the gunner's. GPS mode functionally inactivated the CITV, requiring the commander to use his GPSE, and enabled him to override the gunner in moving the main gun and firing.

Figure 22 represents the percent of time (average per phase) for the offensive scenario that each operating mode was in effect, by duty position. Figure 23 represents this measure for the defensive scenario. The data in Figures 22 and 23 were adjusted for pre-data values prior to analysis (as described in the previous discussion of Pre-data values present in the percent of time in each map scale).

In the offensive scenario there is a main effect for operating mode ($F_{3,124} = 20.52$, $p < .001$), and an effect for the duty position by operating mode interaction ($F_{6,124} = 2.55$, $p < .02$). The same effects were found in the defensive scenario: a main effect for operating mode ($F_{3,128} = 21.68$, $p < .001$), and an effect for the duty position by operating mode interaction ($F_{6,128} = 2.40$, $p < .03$).

Inspection of the data (a table of means and standard deviations for this measure appears in Appendix D) indicates that Co Cdrs rarely operated in the Autoscan mode (7% - 16%), whereas other vehicle commanders operated in this mode from 35% - 43% of the time (across scenarios). Further, Co Cdrs operated in GLOS slightly more often (38% - 46%) than other vehicle commanders (21% - 25%).

Patterns of CITV usage by Co Cdrs may differ from other vehicle commanders because their surveillance requirements were less rigid, having no assigned sectors (resulting in less use of Autoscan). In addition, due to their increased responsibility for C^3, they may have been more likely to allow their gunner to take full responsibility for gunnery (resulting in greater GLOS usage), or they may have used the CITV to a lesser degree, overall (keeping it "parked" over the gunner's shoulder).

CITV operating modes provided vehicle commanders with a number of options. Each of these options were exercised during each scenario. Differential use by duty position was found in the use of Autoscan. However, all vehicle commanders had occasion to use that mode, and the overall pattern of usage more importantly reflects the flexibility required by all echelons and provided by multiple CITV operating modes.

The GPS mode was used very little. GPS should be considered a "non-operating" mode, in that it inactivates CITV function to allow the commander to gain control of and fire from the main

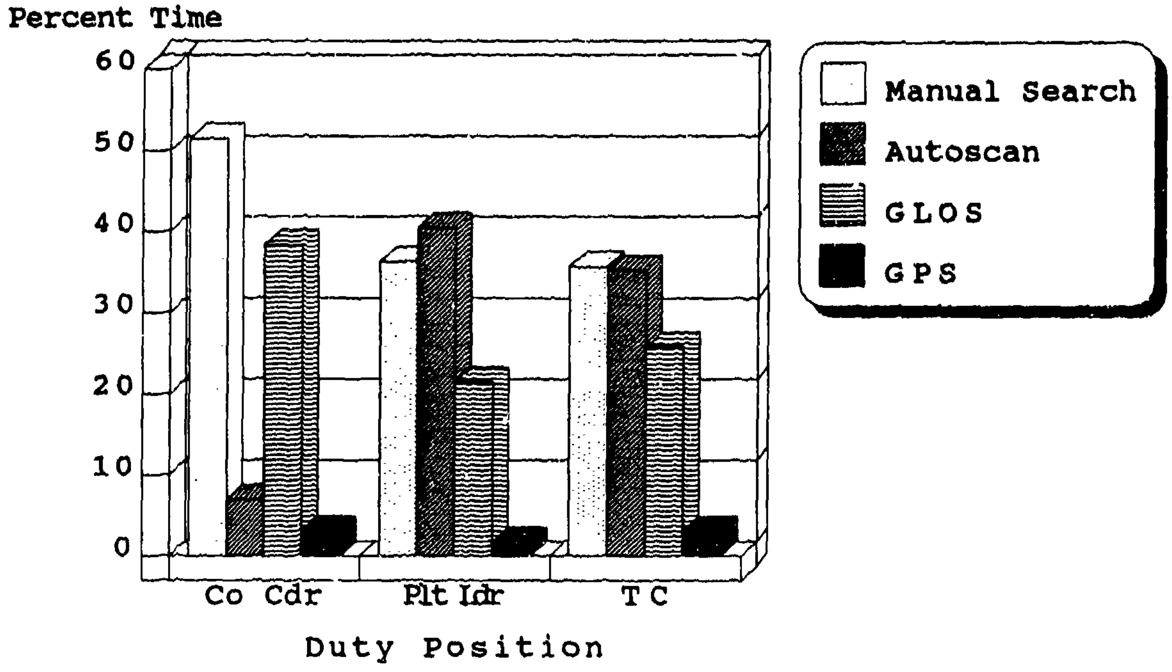

Figure 22. Average percent time per phase in each CITV operating mode, offensive scenario

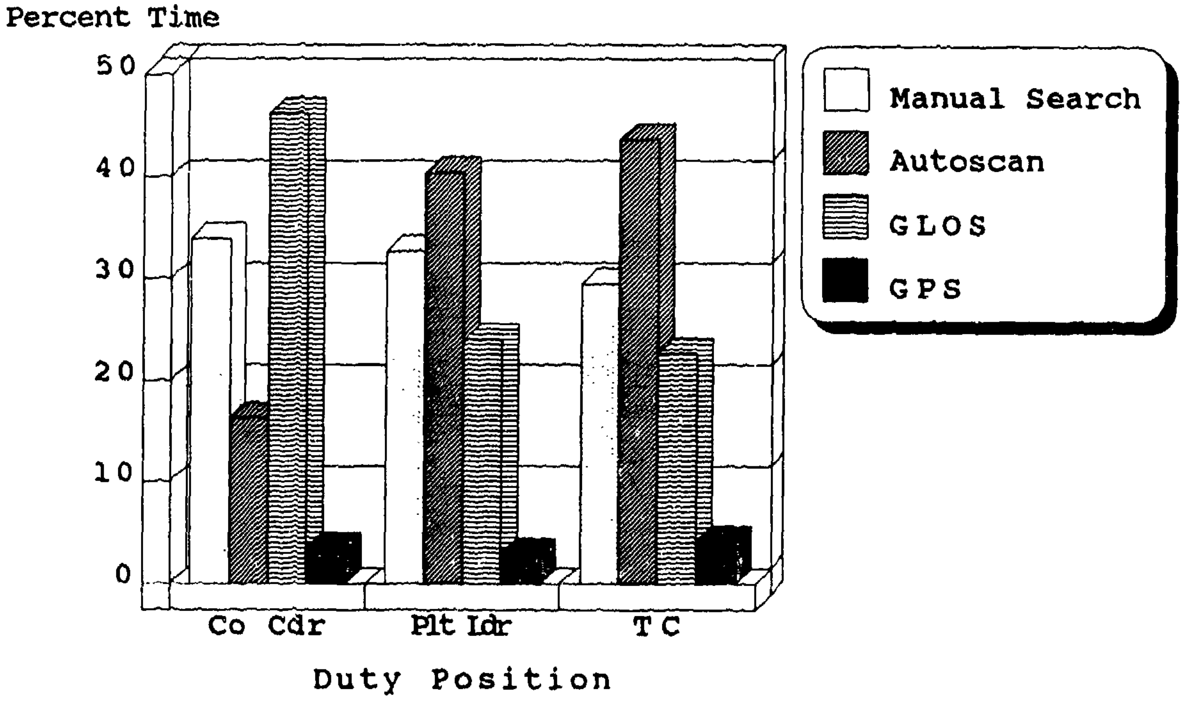

Figure 23. Average percent time per phase in each CITV operating mode, defensive scenario

gun, while using the GPSE. Automated data are not available for the number of rounds fired by the vehicle commander, but the small amount of time spent in GPS indicates that this number would be relatively low. However, 80% of vehicle commanders agreed that they would like to be able to fire the main gun from the CITV.

Vehicle commanders rated most CITV operating functions as easy to use. In addition to changing operating modes, Autoscan sectors were set from one to four times per hour (across scenarios, which ran approximately two and one half hours), with the rate of Autoscan set once or twice per hour. Only one aspect of CITV operating modes presented difficulty: 62% of vehicle commanders indicated that they forgot to switch to GPS before activating the commander's override. Coupled with the requirement to use the GPSE (Quinkert, 1990, also reported problems with this procedure), this latter aspect may have influenced vehicle commander's desire to fire from the CITV.

In summary, rates of usage and perceptions that they are easy to use, indicate that CITV operating modes provide vehicle commanders both useful and usable functions.

<u>Percent of time in each viewing mode</u>. This measure is represented by the average proportion of time per phase each polarity state--black hot and white hot--and each magnification power--3X and 10X--was in effect.

White hot was used, on average, 94% (Std Dev = 19.87) of the time during the offensive scenario and 89% (Std Dev = 24.62) of the time during the defensive scenario. This preference may have been a reflection of general preference or could be due to the fact that the thermal signatures in SIMNET were superior to those in a real tank and white hot offered the better image.

Magnification power was near evenly split between 3X and 10X in both the offensive and defensive scenarios. Vehicle commanders used whichever viewing power was appropriate for the task at hand, switching back and forth between the two powers.

CITV viewing modes provided the ability to easily adjust images to suit requirements and preferences. Vehicle commanders found little wrong with the CITV sight or viewing modes, but suggested that brightness and focus controls be added. Polarity data may be an artifact of the SIMNET environment and care should be taken in extrapolating a strong preference for white hot to a fielded system.

<u>Number of times Designate used.</u> This measure is represented by the cumulative number of times the vehicle commander designated the gunner to a target, slewing the gun tube to the target. Table 14 presents the means and standard deviations for the average number of times Designate was used per phase during the offensive and defensive scenarios. Based on ANOVA, there was

an effect of duty position in the offensive scenario ($F_{2,31} = 3.23$, $p < .05$), but no effect in the defensive scenario.

Designate was not used frequently. The pattern of use is consistent with duty position. Based on the amount of C^3 responsibilities, Co Cdrs should be the least involved in the actual fighting of a battle, and thus should use this feature the least. TCs, on the other hand, should be least involved with C^3 responsibilities and most involved in engagements, with greater use of Designate. As expected, Plt Ldrs were intermediate with respect to amount of C^3 responsibility and use of Designate.

The duty position effect on use of Designate might suggest that Co Cdrs' and Plt Ldrs' tanks were less involved in target engagement. However, Leibrecht, et al. (in preparation) found that Co Cdrs' and Plt Ldrs' vehicles accounted for their "fair share" of rounds fired. That is, if all seven vehicles in a company fired equally, each would fire about 14% of the expended rounds. Indeed, they found that Co Cdrs' and Plt Ldrs' vehicles, equipped with CVCC, fired about 14.90% (Std Dev = 14.4) of all rounds during the offensive scenario and 15.60% (Std Dev = 7.80) during the defensive scenario.

Table 14

Average Number of Times Designate Used per Phase: Means and Standard Deviations (in parentheses)

Position	Offensive Scenario	Defensive Scenario
Co Cdr	.40 (.28) N=5	.93 (1.40) N=5
Plt Ldr	1.84 (1.47) N=15	2.62 (1.63) N=15
TC	2.86 (2.51) N=14	3.63 (2.90) N=15

The overall infrequent use of Designate was likely to have been influenced by scenario structure. Enemy vehicles were encountered in formation. Thus, a single Designate brought the gunner to a cluster of targets, making further use of Designate unnecessary.

Designate is an important feature of the CITV, allowing the vehicle commander to independently detect targets and rapidly bring his gunner to those targets. The infrequent use by Co Cdrs may indicate that higher echelons have less of a need for this feature. However, this finding is mediated by the orderly array of enemy targets. Future evaluations, involving higher echelons and greater numbers of Co Cdrs, may provide additional support for the tailoring of CITV functions to echelon.

Number of targets entered in Target Stack. This measure is represented by the cumulative number of times the vehicle commander entered targets in any of the four Target Stack positions. Table 15 presents the means and standard deviations for the average number of targets entered into Target Stack per phase of the offensive and defensive scenarios. No effect for duty position was found for this measure, although the usage pattern generally follows that for the Designate function.

Table 15

Average Number of Targets Entered in Target Stack per Phase: Means and Standard Deviations (in parentheses)

Position	Offensive Scenario	Defensive Scenario
Co Cdr	1.47 (3.28) N=5	.27 (.36) N=5
Plt Ldr	1.04 (2.46) N=15	1.22 (1.42) N=15
TC	2.28 (3.33) N=14	2.13 (3.12) N=15

The Target Stack feature also was used infrequently. Bearing on this is the fact that prioritization of targets was not automated. Upon initial entry, Target Stack position indicated priority. After a target was fired, or if priorities changed, targets had to be re-entered in the new priority order. Infrequent use may have been a result of cumbersome re-prioritization demands, or Target Stack use and re-prioritization may have required more training time than was available. Atwood et al. found that the Target Stack function was perceived as difficult to use and that more training time was needed.

When asked how they used Target Stacking, 86% of vehicle commanders stated they did not use this feature and 23% stated that the CITV would be improved by eliminating it. However, 20% of vehicle commanders indicated that Target Stacking was useful for electronic range cards and marking target reference points. Only 25% agreed that it was easy to hand off targets to the gunner using Target Stacking. This latter finding is consistent with Quinkert's (1990) finding that abbreviated fire commands and crew coordination training were necessary. Further support for this is reflected in the opinion of 60% of the gunners, who suggested a need for new fire commands with both Designate and Target Stacking.

Gunners' reactions to Target Stacking parallel vehicle commanders. Forty-two percent of gunners indicated that Target Stacking was not useful while moving or not useful at all. However, 54% felt that Designate and Target Stacking would enable them to destroy more targets, and only 24% disagreed. Figure 24 represents the response distribution for this evaluation item (Note that of the thirty-five gunners participating in the evaluation, two had previously participated as drivers and were not asked to complete the Gunner's Equipment Evaluation).

The results bearing on the usefulness and usability of Target Stacking indicate problems in both areas. Automating target prioritization and methods for improving operating procedures, such as target tracking and the presentation of target information in the gunners primary sight, should be investigated.

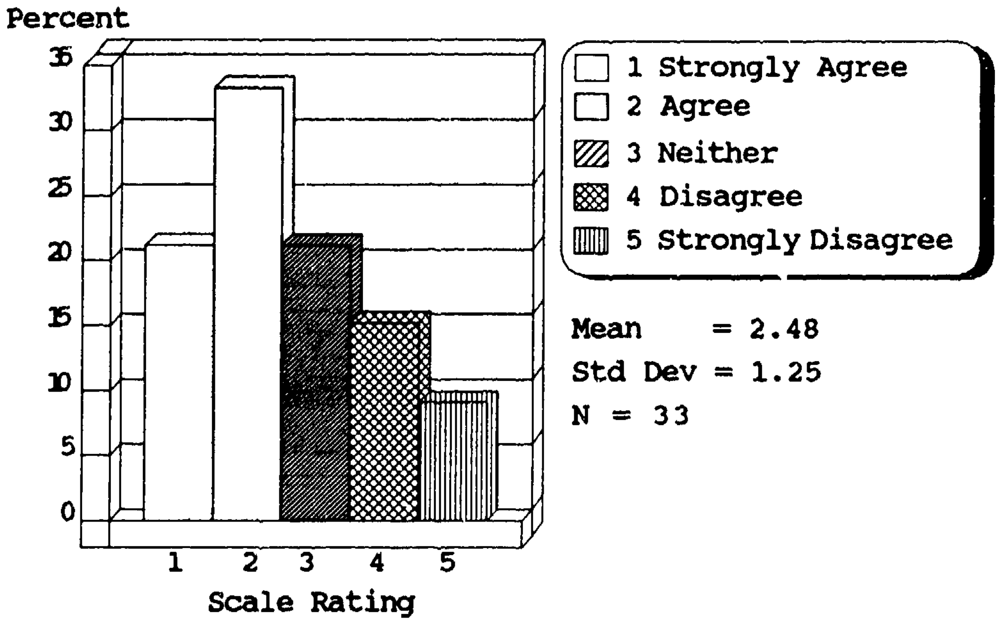

Figure 24. Gunner response distribution: In a real tank, I feel the Target Stacking and Designate equipment would enable me to destroy more targets.

<u>CITV Summary</u>

Overall usefulness and usability of the CITV (with the exception of Target Stacking) were supported by equipment usage measures and evaluation items, the majority of which received favorable ratings. Vehicle commanders indicated that they used the CITV to maintain command and control, scan sectors, and for target detection, searching for additional targets while their gunner was engaged. Eighty-six percent of vehicle commanders agreed that the CITV would improve their real world performance as tank commanders and 89% agreed that the CITV enabled them to attribute more responsibility to their gunner.

CVCC Summary

On the whole, data support the finding that the CVCC is a useful and usable system. Each component provided unique capabilities which vehicle commanders, gunners, and drivers indicated would improve their performance. Further, as a whole, CVCC enabled vehicle commanders to delegate more responsibility to each crewmember for their respective duties, thus freeing up the vehicle commander's time to devote to his own responsibilities.

Areas of improvement, notably the CCD report functions and CITV Target Stacking, have been noted, as have training issues, both in the area of crew coordination and equipment proficiency. As future evaluations incorporate higher echelons, investigations of differential equipment use by echelon, and therefore CVCC design, will be of interest. Few results indicate such is necessary at the company level. The two areas where differences with potential design impact were found were 1) report functions--Co Cdrs originated different types of reports and, overall, relayed more reports; and 2) Co Cdrs used Designate less. These findings, while provocative, are based on only five Co Cdrs, and bear further investigation.

Summary and Recommendations

This section summarizes the results of the SMI evaluation. For each CVCC component we sought to determine the usability and usefulness of component features. The major findings are presented in the following paragraphs. The final section offers recommendations for improving the CVCC SMI.

Summary of Key Findings

CCD Input Devices

Most vehicle commanders found it difficult to use the Thumb Cursor, preferring the Touch Screen method, which was perceived as easier and more accurate. Input was accomplished nearly 90% of the time using the Touch Screen.

CCD Navigation

Vehicle commanders indicated that the Navigation/POSNAV function was easy to use and one of the features which most improved their tactical performance. The ability to send waypoints to the driver allowed vehicle commanders to delegate more responsibility to that crewmember and eliminated the need to continuously direct the driver, resulting in labor savings for themselves. Further utility was gained by the ability to direct subordinates by transmitting navigation routes. These findings parallel those of Du Bois and Smith (1990).

Drivers found the Drivers Display easy to use and agreed that it would improve their performance in a real tank--enabling them to better navigate. Drivers suggested the addition of compass points to the Steer-To Indicator to facilitate navigation.

The Tactical Map

Sixty-five percent of vehicle commanders stated that the Tactical Map and graphic overlays most improved their performance. Du Bois and Smith (1990) also found the Tactical Map to be a critical IVIS function. Lickteig (1986) contended a need for a Tactical Map which would allow vehicle commanders to tailor the map to their task requirements. Automated data indicated that commanders did so, and in so doing, found it to be more helpful than a paper map.

Co Cdrs demonstrated map scale preferences different from their subordinates. All vehicle commanders preferred the 1:50,000 scale. The second preference of Co Cdrs was 1:125,000, whereas the second preference of other vehicle commanders was 1:25,000. This difference may be a reflection of differing echelon requirements--higher echelons having responsibility for more terrain--but is not thought to reflect a need for map design based on echelon.

While vehicle commanders found the Tactical Map functions easy to use, they suggested a more readily available method for scrolling the map. While working with report or navigation routes, they frequently had need to scroll the map to view the area of interest, but first had to exit the current function to do so.

CCD Report Functions

The ability to rapidly disseminate information by means of digital burst is an important component of automated C^3, and was viewed as such by many vehicle commanders. The utility of this function was demonstrated by the high percentage of reports sent via the CCD (as opposed to radio) and the relatively low number of digital reports necessary over a scenario phase.

The ability to input grid locations to reports using the CITV laser device is a useful feature which increases the accuracy of reported locations. While few Co Cdrs used this method, the remaining vehicle commanders used it up to fifty percent of the time. Differential use of this feature was consistent with the type of reports originated by company commanders, which contained fewer enemy locations.

Vehicle commanders stressed the need to improve the report function, however, based on lengthy preparation demands, incorrect formats, and overload associated with the volume of report traffic. The volume of report traffic resulted in many vehicle commanders feeling distracted from the battle.

Analysis of automated and questionnaire data supported the usability problem reported by commanders. The problem centered around the lack of feedback on report status--knowing what actions had already been performed on a report or whether the report had been received. This led vehicle commanders to repeatedly send reports they themselves had originated or to repeatedly relay reports they had received from other vehicle commanders. These redundant report actions resulted in lengthy Receive Queues containing duplicate copies of the same reports. A secondary factor contributing to lengthy Receive Queues may have been lack of understanding, on the part of vehicle commanders, of the net structure and the cost of redundant report actions.

CCD Summary

Vehicle commanders found the CCD to be an important CVCC component which would improve their ability to command their tanks. They found it easy to use and understand, which is consistent with Atwood, et al. (in publication), and Du Bois and Smith (1990), who found that vehicle commanders rated the CCD functions easy to learn.

The CITV

As in previous evaluations (Quinkert, 1990; U.S. Army Armor Center, 1988), the CITV was rated very favorably and most functions were found easy to use. Vehicle commanders found the CITV to be extremely useful and felt that it would improve their ability to command their tanks. The CITV also enabled commanders to give more responsibility to their gunners, freeing more of their time for command and control activities.

Gunners rated the equipment at their crew station very positively, and agreed that it would improve their performance in a real tank--enabling them to acquire more targets. However, vehicle commanders and gunners expressed difficulty in target hand off, supporting Quinkert's (1990) finding that additional crew coordination training will be necessary.

Vehicle commanders reported using the CITV for maintaining unit control and formation, scanning sectors, and target detection. The automated CITV usage data demonstrated that company commanders spent about two thirds less time in the Autoscan mode than did other vehicle commanders. This latter finding may be a reflection of less rigid surveillance requirements for Co Cdrs, less involvement in target detection, or an overall decrease in CITV usage by this echelon.

Rate of usage for both the Designate and Target Stack functions were low. Infrequent use of Designate may have been a result of scenario structure, where enemy vehicles were encountered in formation, precluding the need for frequent designating. Vehicle Commanders found Designate easy to use and useful, both for its intended function and for assigning scanning sectors to the gunner. Co Cdrs used this feature less than other commanders, perhaps a reflection of their increased C^3 demands and lesser involvement in target acquisition. Future evaluations, involving higher echelons and greater numbers of Co Cdrs should further explore this finding.

Low usage rates for Target Stacking and questionnaire responses indicated a usability problem. Most vehicle commanders reported that this function was hard to use. Target Stacking required vehicle commanders to keep track of target priority and to re-enter targets if priority changed. Lack of use may also reflect a need for training above what was provided. Most vehicle commanders suggested elimination of the Target Stack function, but full automation of the function may increase usefulness and usability.

CVCC Summary

Relatively few problems in usability were found with the current CVCC configuration. In many cases, improvements have already been made to address these problems. Other improvements are underway or in the planning stages and will be implemented prior to the next evaluation.

Participants expressed overall approval of the CVCC and used all functions available to them. This did not preclude critical examination of the equipment and suggestions for improvement. Many suggestions were salient and demonstrated the ability of participants to provide valuable input to the design process.

Few findings support tailoring CVCC design to echelon, although some differential use occurred. Preliminary findings which potentially impact design concerned CCD reports--type of reports originated and number of reports relayed--and the use of the CITV Designate function. These differences should be investigated in future evaluations including greater numbers of Co Cdrs and higher echelons.

The focus of echelon-based design should be the ability to configure CVCC software based on echelon (or some other factors), not on building multiple CVCC models, each accommodating different functionality. A re-configurable CVCC, in addition to being more cost effective, would allow the transfer of personnel from one tank to another, given the failure of a system, without a loss of function.

Recommendations for CVCC Improvement

Results of the SMI evaluation lead to a small number of recommendations for improvement to the SMI. It is important to note that overall the current CVCC configuration was very well accepted and viewed as a useful tool which would enhance tank crew performance.

User based testing has been an important element in the development and refinement of the CVCC. Some of the findings presented in this report echo previous findings. Each iteration of CVCC components and their integration has sought to improve design and address findings reflecting usability problems. Only continuous testing can determine the impact of improvements and ensure appropriate implementation. Future evaluations with continued user focus will determine the effectiveness of current improvements and with new functionality will, undoubtedly, uncover areas needing further refinement.

Provide Alternative Input Methods

Vehicle commanders reported that the Touch Screen method was the more accurate and easier method to use. This method was used nearly 90% of the time. However, providing two input devices will allow a backup capability, in the event of a failure, and accommodate personal preference and differences in manual dexterity. It is not clear that the second input device should remain the Thumb Cursor. Vehicle commanders reported difficulty in manipulating the Thumb Cursor on the control handle, as well as accurately placing the cursor on the display. Alternative input devices, such as a light pen or trackball should be investigated.

Ensure Adequate Feedback

Of primary concern in an automated system is the adequacy of feedback. The CCD provided important feedback on system status. Confirmatory messages were displayed when reports were sent and an icon indicated "busy" when the map was being rescaled or other changes in state occurred.

However, given that CCD response time was perceptible and during very busy periods it could be quite slow, selections did not always result in immediate response. Vehicle commanders reported (and RAs confirmed) that they did not know if the system had accepted the input or if it should be made again. This often resulted in repeated (and sometimes random) button pushes, some of which were accepted and resulted in system action--not always related to the intended action.

Already implemented for the future CVCC configuration is a visual indication that input has been made. Each time an action (e.g., SEND, POST, etc.) is selected the soft switch becomes highlighted to indicate input acknowledgement. This feedback should improve confidence in the CCD and eliminate repeated and sometimes costly "button pushes".

Provide Easy Access Map Functions

The process of moving from a report preparation, or other process, to the map function in order to scroll and then moving back to the original function was lengthy and frustrating. Vehicle commanders requested ready access to map functions which would enable them to better utilize other system functions.

Already implemented for the future CVCC configuration is a dedicated scroll key. This will eliminate the need to exit from the current function (for example, creating a report or navigation route) to view a different area of the Tactical Map.

Recommendations for the Driver's Display

Add cardinal direction to the Steer-to-Display. Providing cardinal direction on the Steer-to-Display should enhance the information available to drivers, and facilitate navigation. Drivers and vehicle commanders stated that navigation instructions are typically based on cardinal direction.

Signal arrival at waypoint. An auditory cue should alert drivers to arrival at a waypoint, or to a change in waypoint as it autoadvances, as they are generally looking through vision blocks while navigating and may not be aware that a change in direction is necessary.

Enhance Report Function

Using the existing fielded system, vehicle commanders obtain information visually from vision blocks and the open hatch and auditorially from verbal reports. This allows process sharing between the two modalities. With the CVCC, vehicle commanders must process most information visually. This wholly visual process places additional responsibility on the visual system, eliminating the auditory mode for processing reports and reducing the available time for processing "outside" information from vision blocks and open hatch. This, coupled with excessive numbers of reports, sometimes made vehicle commanders feel as if they were taken out of the battle by the demands of the CCD.

The current implementation of the report function placed undue processing demands on vehicle commanders. The following improvements to the report function should enhance the usability and usefulness of the report function.

Provide report status feedback. The results of this evaluation indicated that excessive demands made by the report function were due, in part, to the proliferation of duplicate reports resulting from redundant report actions. Report status feedback will reduce redundant report actions--multiple sends and/or relays of the same report--resulting in a reduction to the number of reports in Receive Queues and the number of report icons automatically posted to the Tactical Map.

Improvements made since the Company evaluation for the future CVCC configuration include visual status indicators for each report in the Receive Queue and each old file. Without having to open a report, the vehicle commander can see whether he has read, sent (for self-originated reports), or relayed (for other-originated reports) it.

Filter duplicate reports. The current CCD configuration permitted duplicate copies of reports to be displayed in the Receive Queue (and old files). Excessive review demands can be curtailed by the elimination of duplicate reports. The elimination of duplicate reports from the Receive Queue has been implemented for the future CVCC configuration, but further processing to eliminate duplicate reports from old files should be pursued. (Duplicate copies of a report can enter the Receive Queue if the original report has already transferred into or otherwise been placed in an old file. Subsequent copies can then transfer into that old file.)

Provide report aggregation. Further reduction in excessive report demands can be accomplished by aggregating reports which contain similar information and providing a single, summary report. Similar reports result when multiple reports contain the same or very similar information, as when three TCs send their Plt Ldr a SHELL report on the same shelling event. Under study for the future CVCC configuration is the aggregation of like reports (based on report type, time, and location of the reported event) which would result in a significant reduction to the Receive Queue and concomitant decluttering of the Tactical Map. Further, it would automate the integration of information, further reducing demands on vehicle commanders.

Provide report acknowledgement. Some reports were re-transmitted because of the lack of confirmation that a report had been received. Also under investigation for the future CVCC configuration is a method for providing receipt acknowledgement which would reduce re-transmissions.

Improve report icons and report formats. Important in the acceptance of new technologies is conformance to established standards, in this case, military standards. Report icons should conform to NATO and military symbology as outlined in FM 101-5-1, and report formats should conform to standards appropriate to the reporting echelon, such as FM 17-25.

To illustrate, the icon used to depict an NBC chemical attack was a beaker with a rod in it. Standard military symbology dictates that a round-bottom flask shape be used to denote a chemical agent, with the letters "CML" to the left of the shape. The same symbol is used to denote a biological agent with the letters "BIO". Under development is a revised symbol library which will incorporate the appropriate symbology for report icons and reduce the number of generic icons currently in use.

Report formats are equally important. For example, a CONTACT report is a quick report which consists of three parts: the alert, a target description (if known), and a cardinal direction. The CCD CONTACT report requires a grid location and substantially reduces the alerting nature and quickness of the report. A repeated recommendation by participants (U.S. Army Armor Center, 1988; Du Bois and Smith, 1990) has been the elimination of the CONTACT report from the CCD repertoire, because it lacks the urgency associated with this alert. Improvement to the CONTACT report format might improve perceptions of its usefulness.

Report formats should also be improved to eliminate unnecessary length. For example, the first page of an NBC report requires the user to select whether the agent was nuclear, chemical, or biological. Regardless of the selected agent, the second page of the report requires the user to indicate the size and depth of the nuclear impact. In general, multi-page reports should be avoided, and in this case, the second page of the report should not be presented when chemical or biological has been selected on the first page.

Automate vehicle status report input. Status reports can be improved by automating information (fuel, ammunition, and equipment) input to SITUATION reports for more timely and accurate reporting. This information would be useful not only for transmittal, but also for providing vehicle commanders with information concerning vehicle status. AMMUNITION reports currently provide this automated input based on a Green-Amber-Red-Black code. This report will be enhanced for the future CVCC configuration to provide actual percentages as well as the Green-Amber-Red-Black code.

Provide user configuration capability. Some differences in report utilization between duty positions emerged from the analysis of automated data. Co Cdrs originated less front-line action types of reports and relayed more reports of all types than did Plt Ldrs and TCs. It would be useful to provide customization of quick access report keys. While Plt Ldrs and TCs may need the existing quick access report keys (CONTACT, SPOT, and NBC), Co Cdrs may benefit from quick access keys such as RELAY UP and RELAY DOWN.

CITV Recommendation

Automate Target Stacking. The Target Stack function was perceived as too time consuming and hard to use. Automation of this function should substantially improve perceived usefulness and usability. Automated functions should include advance of targets in the stack to reflect new priorities and target tracking.

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Appendix A

Soldier-Completed Instruments

Appendix A contains the following instruments:

Wk   **Sim Dty Pos: TC**   **Sim Call # A_____**

CCD EVALUATION

We would like to get your expert opinion on the CCD system you used this week. Your **confidential** responses will be used to improve future versions of the M1. Please respond to the following questions by entering the number of the scale that best represents your opinion.

1	2	3	4	5
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

_____ 1. The Tactical Map is too small.

_____ 2. The CCD display often presented too much information.

_____ 3. Map icons and symbols were easy to understand.

_____ 4. The Tactical Map would not be useful without the added Report Menu functions.

_____ 5. I frequently changed the scale of the Tactical Map.

_____ 6. It was easy to scroll the Tactical Map.

_____ 7. The Tactical Map with **POSNAV** is more helpful for navigating than a paper map.

_____ 8. I usually touched the map, instead of lasing to the target, when entering grid coordinates into reports.

_____ 9. The touch screen made it easy to operate the CCD.

_____ 10. The touch method was an accurate method of operating the display.

_____ 11. The thumb control was easy to use.

Comments:____

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CCD EVALUATION

1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree

_____ 12. It was difficult to operate the thumb control because the front finger switches were in the way.

_____ 13. Using overlays on the Tactical Map was easier than using grease pencils and lap maps.

_____ 14. I would like to be able to edit overlays sent to me.

_____ 15. The terrain features were distracting.

_____ 16. I frequently posted symbols to my Tactical Map.

_____ 17. I used CCD information when assigning CITV sectors.

_____ 18. I spent more time looking at CITV than I did looking at the CCD.

_____ 19. By sending waypoints, I was able to give the driver more responsibility.

_____ 20. I needed to input more than 6 waypoints at a time.

_____ 21. It was easy to change the waypoints.

_____ 22. Having different tank icons on the CITV and the CCD was confusing.

_____ 23. It was easy to create reports on the CCD.

_____ 24. It was difficult to manage all of the reports sent to me over the CCD.

_____ 25. I spent too much time getting CFF and Adjust for Fire messages out with the CCD system.

Comments: ____

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CCD EVALUATION

1	2	3	4	5
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

_____ 26. It took me longer to create and send a **SPOT** report with the CCD than it would have taken me to send it over the radio.

_____ 27. The reports I **received** over CCD still contained valuable information by the time I read them.

_____ 28. I had enough time to read all of my messages.

_____ 29. I did not need to know the type and number of messages sent to me.

_____ 30. There is enough space in the Menu Window to make choices and prepare reports using the touch method.

_____ 31. It was easy to read the information presented in the **Information Center** (ie. DTG, Heading, Alert Status).

_____ 32. I had trouble understanding the abbreviations used in the menu area.

_____ 33. I found it easy to move from one menu to the next.

_____ 34. It was useful to have automated prompts (highlighted areas) in the reports.

_____ 35. I found having several highlighted fields at one time in the reports to be confusing.

_____ 36. When entering route waypoints, I prefer to enter grid coordinates with the thumb control rather than touching the map.

_____ 37. The commander's override control contains too many functions.

Comments:____

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CCD EVALUATION

1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree

_____ 38. I trusted the information presented to me on the CCD.

_____ 39. I spent more time looking at the CCD system than I did looking through the vision blocks and sights.

_____ 40. I spent less time looking at the CCD than I tactically should have.

_____ 41. The tank icon on the CCD helped me keep track of my direction.

_____ 42. Using the CCD did not strain my eyes.

_____ 43. The technical difficulties I experienced with my CCD (if any) did not interfere with my ability to command my tank.

_____ 44. I feel the CCD would improve my "real world" performance as a tank commander.

45. What features of the CCD system improved your combat mission performance the most?

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Comments:____

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CCD EVALUATION

46. What features of the CCD system degraded your combat mission performance?

47. Which reports would you prefer to send over the radio instead of the CCD?

48. How would you prefer to make inputs to the CCD (thumb control, touch, or other means)?

49. How would you change the CCD?

PT 5838

Wk Sim Dty Pos: TC Sim Call # A_____

CITV EVALUATION

We would like to get your expert opinion on the CITV system you used this week. Your **confidential** responses will be used to improve future versions of the M1. Please respond to the following questions by entering the number of the scale that best represents your opinion.

1	2	3	4	5
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

_____ 1. The CITV screen is too small.

_____ 2. The CITV tank icon was useful for orienting my tank in the proper direction.

_____ 3. The CITV display functions were difficult to use while on the move.

_____ 4. There was too much information on the CITV display screen.

_____ 5. Using the CITV for several hours made my eyes tired or achy.

_____ 6. While my gunner was engaging a target I used the CITV to search for more targets.

_____ 7. The CITV allowed me to give the gunner more responsibility over the target kill assessment.

_____ 8. The CITV enabled me to acquire targets at greater ranges.

_____ 9. The CITV enabled me to acquire targets more quickly.

Comments:____

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CITV Evaluation

1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree

_____ 10. I used the CITV more often than I did the vision blocks and GPSE.

_____ 11. The CITV was useful in controlling fire distribution to prevent target overkill and ammo expenditure.

_____ 12. The CITV was more helpful in defensive than in offensive operations.

_____ 13. The CITV was more helpful in offensive than in defensive operations.

_____ 14. With the CITV I could orient my tank to cover my assigned sectors more rapidly than I could without it.

_____ 15. I used the CITV to maintain unit command and control.

_____ 16. The CITV helped me to identify key terrain features important for command and control.

_____ 17. As the number of targets presented increased, the usefulness of the CITV increased.

_____ 18. I sometimes forgot to switch over to the **GPS Mode** to activate the commander's override.

_____ 19. I rarely used the **Manual Scan** mode.

_____ 20. I would like to be able to fire from the CITV.

_____ 21. The SIMNET CITV thermal signatures provide greater detail than is provided by the thermal systems in tanks.

Comments:____

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CITV Evaluation

1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree

_____ 22. I rarely used the **Target-stacking** function to designate targets to the Gunner.

_____ 23. It was easy to hand-off targets to the Gunner using the **Target-stacking** function.

_____ 24. I prefer to use **AutoScan** in offensive operations more than in defensive operations.

_____ 25. I prefer to use **AutoScan** in defensive operations more than in offensive operations.

_____ 26. It was difficult to change the rate of the **AutoScan**.

_____ 27. The **Manual Search** mode was easy to use.

_____ 28. The IFF function was difficult to use.

_____ 29. I prefer to use the **Target-stacking** function in offensive operations more than defensive operations.

_____ 30. I prefer to use the **Target-stacking** function in defensive operations more than offensive operations.

_____ 31. The technical difficulties I experienced with my CITV (if any) did not interfere with my ability to command my tank.

_____ 32. I feel the CITV would improve my "real world" performance as a tank commander.

Comments:____

CITV Evaluation

33. How did you use the CITV in offensive operations?

34. How did you use the CITV in defensive operations?

35. What ways (different from those trained) did you use the the **Target-stack** function?

36. How would you change the CITV?

PT 5839

Wk Sim Dty Pos: GNR Sim Call # A_____

GUNNER'S EQUIPMENT EVALUATION

We would like to get your expert opinion on some of the equipment you used this week. Your **confidential** responses will be used to improve future versions of the M1. Please respond to the following questions by entering the number of the scale that best represents your opinion.

1	2	3	4	5
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

_____ 1. The classroom instruction was helpful.

_____ 2. I needed more hands-on instruction in the simulator.

_____ 3. The training exercises adequately prepared me for the test scenarios.

_____ 4. The thermal signatures in SIMNET are not accurate.

_____ 5. I liked having my TC designate me on to new targets.

_____ 6. I found it easy to get disoriented when my TC designated me to a target.

_____ 7. The fire commands I use in a real tank were not adequate in the simulator when my TC designated targets.

_____ 8. The fire commands I use in a real tank were not adequate in the simulator when using **Target-Stacking**.

_____ 9. I engaged targets more often in the thermal mode.

_____ 10. The **Target Stacking** function was easy to use.

_____ 11. When using the **Target Stacking** function, I would prefer to designate myself to new targets.

_____ 12. As the number of targets presented increased, the usefulness of the target designate function increased.

Comments:____

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GUNNER'S EQUIPMENT EVALUATION

1 Strongly Agree	2 Agree	3 Neutral	4 Disagree	5 Strongly Disagree

_____ 13. I used the lights on the **Target Stack** panel to determine which direction the turret would move.

_____ 14. I would prefer that the information from the **Target Stack** panel lights be presented in the GPS.

_____ 15. I never need to have 4 targets stacked at any one time.

_____ 16. I would prefer to have the stacked targets automatically prioritized.

_____ 17. Target hand-offs were smooth and allowed me to acquire targets more quickly.

_____ 18. I would prefer the TC make the kill assessment rather than making the gunner responsible for it.

_____ 19. In a real tank, I feel the **Target-Stack** and **Designate** equipment would enable me to destroy more targets.

20. What would be good fire commands to use when your TC designates targets?

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21. What problems, if any, did you have using the new equipment (Target Stack, Designate)?

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Comments: _______________________________________

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PT 5840

Wk Sim Dty Pos: DVR Sim Call # A ______

DRIVER'S EQUIPMENT EVALUATION

We would like to get your expert opinion on the equipment you used during the past week. Your **confidential** responses will be used to help make improvements in future versions of the M1.
Please respond to the following questions by entering the number of the scale which best represents your opinion.

1	2	3	4	5
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

_____ 1. The classroom instruction on the **Driver's Display** was useful.

_____ 2. I needed more hands-on instruction on the **Driver's Display.**

_____ 3. The training exercises adequately prepared me for the test scenarios.

_____ 4. The **Driver's Display** was difficult to use.

_____ 5. I had no trouble receiving waypoints on the **Driver's Display** from my TC.

_____ 6. Fewer communications were needed with the TC because of the **Steer-To** indicator.

_____ 7. I would prefer waypoints to be sent automatically.

_____ 8. In a real tank, I could use terrain features more easily and could maneuver better if I had the **Steer-To** indicator.

_____ 9. The **Steer-To** indicator responds too slowly.

_____ 10. I think drivers would become too dependent on the **Steer-To** display if it was put into a real tank.

Comments: ____

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DRIVER'S EQUIPMENT EVALUATION

1	2	3	4	5
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

_____ 11. My TC sometimes forgot to send me new waypoints.

_____ 12. I would prefer to see all the waypoints at once instead of seeing them one at a time.

_____ 13. Having a **Steer-To** indicator gave me more confidence in moving from point to point.

_____ 14. In a real tank, I feel the **Steer-To** indicator would improve my performance as a Driver.

15. What problems, if any, did you have using the **Driver's Display** and the **Steer-To** indicator?

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16. How would you change the **Driver's Display**?

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17. How would you change the **Steer-To** indicator?

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Comments: ____

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PT 5841

Appendix B

Summary Tables of Statistical Analyses

Appendix B specifically contains the following:

Summaries of **Percent Time In Map Scale**: Offensive Scenario
By levels of Map Scale and Duty Position

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		25.0000	34.9472	112
1:25,000	1.00	17.5421	29.3351	28
1:50,000	2.00	68.4451	31.3775	28
1:125,000	3.00	12.5348	20.4753	28
1:250,000	4.00	1.4780	2.5701	28

*** CELL MEANS ***

	Co Cdr	Plt Ldr	TC
1:25,000	3.53	14.26	25.50
	(4)	(12)	(12)
1:50,000	77.51	71.72	62.15
	(4)	(12)	(12)
1:125,000	18.34	12.00	11.13
	(4)	(12)	(12)
1:250,000	.63	2.02	1.22
	(4)	(12)	(12)

*** ANALYSIS OF VARIANCE ***

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	74249.483	5	14849.897	25.368	.000
SCALE	74249.483	3	24749.828	42.280	.000
POSITION	.000	2	.000	.000	1.000
2-way Interactions	2777.392	6	462.899	.791	.579
SCALE POSITION	2777.392	6	462.899	.791	.579
Explained	77026.874	11	7002.443	11.962	.000
Residual	58537.848	100	585.378		
Total	135564.722	111	1221.304		

Summaries of **Percent Time in Map Scale**: Defensive Scenario
By levels of Map Scale and Duty Position

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		25.0000	33.3195	112
1:25,000	1.00	22.7089	27.5633	28
1:50,000	2.00	64.4662	31.0862	28
1:125,000	3.00	11.8094	20.9310	28
1:250,000	4.00	1.0155	1.4810	28

*** CELL MEANS ***

	Co Cdr	Plt Ldr	TC
1:25,000	.71	20.09	32.66
	(4)	(12)	(12)
1:50,000	80.68	71.65	51.88
	(4)	(12)	(12)
1:125,000	16.31	7.45	14.67
	(4)	(12)	(12)
1:250,000	2.30	.81	.80
	(4)	(12)	(12)

*** ANALYSIS OF VARIANCE ***

Source Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	64738.243	5	12947.649	25.241	.000
SCALE	64738.243	3	21579.414	42.068	.000
POSITION	.000	2	.000	.000	1.000
2-way Interactions	7196.225	6	1199.371	2.338	.037
SCALE POSITION	7196.225	6	1199.371	2.338	.037
Explained	71934.468	11	6539.497	12.748	.000
Residual	51296.305	100	512.963		
Total	123230.772	111	110.187		

Summaries of **Percent of Grid Inputs to Reports by Laser Device:** Offensive Scenario
By levels of Input Mode (LRF vs Map) and Duty Position

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		50.0000	38.4546	54
Laser		20.6845	24.7940	27
Map		79.3155	24.7940	27

*** CELL MEANS ***

	Co Cdr	Plt Ldr	TC
Laser	-.00 (4)	23.44 (12)	25.20 (11)
Map 2	100.00 (4)	76.56 (12)	74.80 (11)

*** ANALYSIS OF VARIANCE ***

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	46407.548	3	15469.183	26.601	.000
MODE	46407.548	1	46407.548	79.803	.000
POSITION	.000	2	.000	.000	1.000
2-way Interactions	4053.434	2	2026.717	3.485	.039
MODE POSITION	4053.434	2	2026.717	3.485	.039
Explained	50460.982	5	10092.196	17.355	.000
Residual	27913.115	48	581.523		
Total	78374.097	53	1478.757		

Summaries of **Percent of Grid Inputs to Reports by Laser Device:** Defensive Scenario
By levels of Input Mode (Laser vs Map) and Duty Position

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		50.0000	35.1424	56
Laser		45.2444	35.1341	28
Map		54.7556	35.1341	28

*** CELL MEANS ***

	Co Cdr 1	Plt Ldr 2	TC 3
Laser	5.20 (4)	57.89 (12)	45.95 (12)
Map 2	94.80 (4)	42.11 (12)	54.05 (12)

*** ANALYSIS OF VARIANCE ***

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	1266.458	3	422.153	.422	.738
MODE	1266.458	1	1266.458	1.267	.266
POSITION	.000	2	.000	.000	1.000
2-way Interactions	16679.605	2	8339.802	8.343	.001
MODE POSITION	16679.605	2	8339.802	8.343	.001
Explained	17946.063	5	3589.213	3.591	.007
Residual	49978.199	50	999.564		
Total	67924.262	55	1234.987		

Summaries of **Median Number of Icons on the Tactical Map: Offensive Scenario**
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	21.1333	12.0591	581.6889	5
2.00	Plt Ldr	27.4778	21.1967	6290.2148	15
3.00	TC	7.5714	5.5974	407.3036	14
Within Groups Total		18.3480	15.3236	7279.2072	34

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	2914.9659	2	1457.4830	6.2070	.0054
Within Groups	7279.2072	31	234.8131		

Eta = .5347 Eta Squared = .2859

Summaries of **Median Number of Icons on the Tactical Map:** Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	19.7000	8.7974	309.57785	5
2.00	Plt Ldr	19.3556	18.9540	5029.5481	15
3.00	TC	10.0778	5.9428	494.4370	15
Within Groups Total		15.4286	13.5018	5833.5630	35

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	752.0085	2	376.0042	2.0626	.1437
Within Groups	5833.5630	32	182.2988		

Eta = .3379 Eta Squared = .1142

Summaries of **Percent Reports Retrieved**: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	57.0551	19.1135	1461.3033	5
2.00	2nd Plt Ldr	31.1444	9.5692	366.2748	5
3.00	TC	30.7643	21.5682	6047.4147	14
4.00	Tethered Plt Ldr	26.8976	13.1294	1551.4356	10
Within Groups Total		33.5492	17.7261	9426.4284	34

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F	Sig. of F
Between Groups	3342.5648	3	1114.1883	3.5460	0261
Within Groups	9426.4284	30	314.2143		

Eta = .5116 Eta Squared = .2618

% REPORTS RETRIEVED - ORTHOGONAL CONTRASTS
Tests of Significance for IAC3 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	9426.43	30	314.21		
CONSTANT	37232.14	1	37232.14	118.49	.000
NPOS(1)	60.12	1	60.12	.19	.665
NPOS(2)	3123.75	1	3123.75	9.94	.004
NPOS(3)	.53	1	.53	.00	.967

Summaries of **Percent Reports Retrieved**: Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	56.4436	16.1134	1038.5634	5
2.00	2nd Plt Ldr	6.2762	7.8466	246.2752	5
3.00	TC	34.3460	25.8340	9343.5612	15
4.00	Tethered Plt Ldr	17.7441	9.7772	860.3499	10
Within Groups Total		31.6066	19.2511	11488.7497	35

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig. of F
Between Groups	5260.7064	3	1753.5688	4.7316	.0079
Within Groups	11488.7497	31	370.6048		

Eta = .5604 Eta Squared = .3141

% REPORTS RETRIEVED - ORTHOGONAL CONTRASTS

Tests of Significance for IAC3 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	11488.75	31	370.60		
CONSTANT	32071.31	1	32071.31	86.54	.000
NPOS(1)	242.66	1	242.66	.65	.425
NPOS(2)	3819.02	1	3819.02	10.30	.003
NPOS(3)	244.21	1	244.21	.66	.423

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Summaries of **Percent of Adjust Fire Reports Relayed**: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	75.0000	35.3553	5000.0000	5
2.00	2nd Plt Ldr	44.3333	36.9985	5475.5555	5
4.00	Tethered Plt Ldr	.0000	.0000	.0000	10
Within Groups Total		29.8333	24.8236	10475.5555	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	20151.6667	2	10075.8333	16.3513	.0001
Within Groups	10475.5555	17	616.2091		

Eta = .8112 Eta Squared = .6580

Summaries of **Percent of Calls for Fire Relayed**: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	73.6111	22.7371	1550.9260	4
2.00	2nd Plt Ldr	68.1250	21.9255	1442.1875	4
4.00	Tethered Plt Ldr	.0000	.0000	.0000	8
Within Groups Total		35.4340	15.1736	2993.1135	16

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	20149.3200	2	10074.6600	43.7573	.0000
Within Groups	2993.1135	13	230.2395		

Eta = .9331 Eta Squared = .8707

Summaries of **Percent of Contact Reports Relayed:** Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	51.9293	23.5704	2222.2548	5
2.00	2nd Plt Ldr	24.1751	13.8188	763.8342	5
4.00	Tethered Plt Ldr	25.8593	15.8260	2254.1512	10
Within Groups Total		31.9558	17.5570	5240.2402	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	2669.0705	2	1334.5353	4.3294	.0302
Within Groups	5240.2402	17	308.2494		

Eta = .5809 Eta Squared = .3375

Summaries of **Percent of Shell Reports Relayed:** Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	26.8077	12.2520	600.4452	5
2.00	2nd Plt Ldr	23.2784	18.3959	1353.6434	5
4.00	Tethered Plt Ldr	10.9481	10.7429	1038.6866	10
Within Groups Total		17.9956	13.2682	2992.7752	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	1024.4758	2	512.2379	2.9097	.0819
Within Groups	2992.7752	17	176.0456		

Eta = .5050 Eta Squared = .2550

Summaries of **Percent of Situation Reports Relayed**: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	14.7619	24.7665	2453.5147	5
2.00	2nd Plt Ldr	3.9444	5.4020	116.7284	5
4.00	Tethered Plt Ldr	.0000	.0000	.0000	10
Within Groups Total		4.6766	12.2960	2570.2431	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	729.9530	2	364.9765	2.4140	.1195
Within Groups	2570.2431	17	151.1908		

Eta = .4703 Eta Squared = .2212

Summaries of **Percent of Spot Reports Relayed**: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	51.7778	27.6000	3047.0345	5
2.00	2nd Plt Ldr	11.3169	12.2326	598.5465	5
4.00	Tethered Plt Ldr	19.8637	16.2900	2388.2775	10
Within Groups Total		25.7055	18.8397	6033.8585	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	4775.2363	2	2387.6182	6.7270	.0070
Within Groups	6033.8585	17	354.9329		

Eta = .6647 Eta Squared = .4418

Summaries of **Percent of Intelligence Reports Relayed**: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	93.3333	9.1287	333.3333	5
2.00	2nd Plt Ldr	84.4444	12.0442	580.2469	5
4.00	Tethered Plt Ldr	47.7778	41.9190	15814.8147	10
Within Groups Total		68.3333	31.3691	16728.3950	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	8648.1481	2	4324.0741	4.3943	.0290
Within Groups	16728.3950	17	984.0232		

Eta = .5838 Eta Squared = .3408

Summaries of **Percent of FRAGOs Relayed**: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	100.0000	.0000	.0000	5
2.00	2nd Plt Ldr	78.3333	21.7307	1888.8889	5
4.00	Tethered Plt Ldr	72.5000	41.5832	15562.5000	10
Within Groups Total		80.8333	32.0399	17451.3889	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	2562.5000	2	1281.2500	1.2481	.3121
Within Groups	17451.3889	17	1026.5523		

Eta = .3578 Eta Squared = .1280

Summaries of **Percent of NBC Reports Relayed:** Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	43.3333	9.1287	333.3333	5
2.00	2nd Plt Ldr	45.7143	36.6311	5367.3469	5
4.00	Tethered Plt Ldr	15.0000	31.8658	9138.8889	10
Within Groups Total		29.7619	29.5451	14839.5691	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	4372.4490	2	2186.2245	2.5045	.1114
Within Groups	14839.5691	17	872.9158		

Eta = .4771 Eta Squared = .2276

Summaries of **Percent of Total Reports Relayed:** Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	56.8921	12.9296	668.6958	5
2.00	2nd Plt Ldr	38.5821	7.7729	241.6692	5
4.00	Tethered Plt Ldr	20.5463	12.5537	1418.3486	10
Within Groups Total		34.1417	11.7040	2328.7135	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	4534.8324	2	2267.4162	16.5525	.0001
Within Groups	2328.7135	17	136.9831		

Eta = .8128 Eta Squared = .6607

% TOTAL REPORTS RELAYED - ORTHOGONAL CONTRASTS
OFFENSIVE SCENARIO

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests of Significance for RELAYA using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	2328.71	17	136.98		
CONSTANT	26921.53	1	26921.53	196.53	.000
Duty Position(1)	1084.30	1	1084.30	7.92	.012
Duty Position(2)	2715.68	1	2715.68	19.82	.000

Summaries of **Percent of Adjust Fire Reports Relayed**: Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	46.7063	40.6227	6600.8252	5
2.00	2nd Plt Ldr	5.3788	6.8413	187.2130	5
4.00	Tethered Plt Ldr	.0000	.0000	.0000	10
Within Groups Total		13.0213	19.9824	6788.0382	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	7660.9952	2	3830.4976	9.5931	.0016
Within Groups	6788.0382	17	399.2964		

Eta = .7282 Eta Squared = .5302

Summaries of **Percent of Calls for Fire Relayed**: Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	66.0238	20.9422	1754.2971	5
2.00	2nd Plt Ldr	14.7037	18.1168	1312.8670	5
4.00	Tethered Plt Ldr	2.2222	6.6667	355.5556	9
Within Groups Total		22.2967	14.6260	3422.7196	19

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	13475.4304	2	6737.7152	31.4964	.0000
Within Groups	3422.7196	16	213.9200		

Eta = .8930 Eta Squared = .7975

Summaries of **Percent of Contact Reports Relayed**: Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	50.9325	17.9607	1290.3424	5
2.00	2nd Plt Ldr	25.4957	18.5568	1377.4220	5
4.00	Tethered Plt Ldr	18.2053	15.7354	2228.4225	10
Within Groups Total		28.2097	16.9709	4896.1869	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	3619.3523	2	1809.6762	6.2834	.0091
Within Groups	4896.1869	17	288.0110		

Eta = .6519 Eta Squared = .4250

Summaries of **Percent of Shell Reports Relayed**: Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	40.4785	28.6357	3280.0164	5
2.00	2nd Plt Ldr	20.7948	13.0661	682.8947	5
4.00	Tethered Plt Ldr	15.0248	14.4835	1887.9573	10
Within Groups Total		22.8307	18.5518	5850.8684	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	2187.2619	2	1093.6309	3.1776	.0672
Within Groups	5850.8684	17	344.1687		

Eta = .5216 Eta Squared = .2721

Summaries of Percent of Spot Reports Relayed: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	40.6616	27.3323	2988.2160	5
2.00	2nd Plt Ldr	14.8809	13.0024	676.2479	5
4.00	Tethered Plt Ldr	9.9021	10.3493	963.9783	10
Within Groups Total		18.8367	16.5003	4628.4423	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	3258.1431	2	1629.0716	5.9835	.0108
Within Groups	4628.4423	17	272.2613		

Eta = .6427 Eta Squared = .4131

Summaries of **Percent of Intelligence Reports Relayed:** Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	83.3333	16.6667	1111.1111	5
2.00	2nd Plt Ldr	63.2222	29.2509	3422.4691	5
4.00	Tethered Plt Ldr	44.4444	43.2716	16851.8518	10
Within Groups Total		58.8611	35.4678	21385.4321	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	5167.9476	2	2583.9738	2.0541	.1588
Within Groups	21385.4321	17	1257.9666		

Eta = .4412 Eta Squared = .1946

Summaries of **Percent of FRAGOs Relayed**: Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	95.0000	11.1803	500.0000	5
2.00	2nd Plt Ldr	62.7778	25.9540	2694.4444	5
4.00	Tethered Plt Ldr	50.8333	47.7018	20479.1667	10
Within Groups Total		64.8611	37.3171	23673.6111	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	6531.2500	2	3265.6250	2.3450	.1261
Within Groups	23673.6111	17	1392.5654		

Eta = .4650 Eta Squared = .2162

Summaries of **Percent of NBC Reports Relayed**: Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	67.5000	39.4757	4675.0000	4
2.00	2nd Plt Ldr	35.0000	47.2582	6700.0000	4
4.00	Tethered Plt Ldr	11.6667	20.4124	2083.3333	6
Within Groups Total		34.2857	34.9783	13458.3333	14

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	7484.5238	2	3742.2619	3.0587	.0879
Within Groups	13458.3333	11	1223.4848		

Eta = .5978 Eta Squared = .3574

Summaries of Percent of Total Reports Relayed: Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	52.4890	8.2111	269.6913	5
2.00	2nd Plt Ldr	24.6952	7.6269	232.6788	5
4.00	Tethered Plt Ldr	16.2449	11.7172	1235.6430	10
Within Groups Total		27.4185	10.1112	1738.0130	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	4428.2310	2	2214.1155	21.6569	.0000
Within Groups	1738.0130	17	102.2361		

Eta = .8474 Eta Squared = .7181

% TOTAL REPORTS RELAYED - ORTHOGONAL CONTRASTS
DEFENSIVE SCENARIO

* * ANALYSIS OF VARIANCE -- DESIGN 1 * *

Tests of Significance for RELAYA using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	1738.01	17	102.24		
CONSTANT	17457.98	1	17457.98	170.76	.000
Duty Position(1)	238.02	1	238.02	2.33	.145
Duty Position(2)	3728.06	1	3728.06	36.47	.000

Summaries of **Total Number of Reports Relayed**: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	5.2667	1.0382	4.3111	5
2.00	2nd Plt Ldr	3.6667	1.1785	5.5556	5
4.00	Tethered Plt Ldr	5.8833	4.1096	152.0028	10
Within Groups Total		5.1750	3.0857	161.8694	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	16.4347	2	8.2174	.8630	.4396
Within Groups	161.8694	17	9.5217		

Eta = .3036 Eta Squared = .0922

Summaries of **Total Number of Reports Relayed**: Defensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	9.6000	4.3102	74.3111	5
2.00	2nd Plt Ldr	4.5333	4.0593	65.9111	5
4.00	Tethered Plt Ldr	4.3000	2.7463	67.8778	10
Within Groups Total		5.6833	3.4987	208.1000	20

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	102.4500	2	51.2250	4.1846	.0333
Within Groups	208.1000	17	12.2412		

Eta = .5744 Eta Squared = .3299

Summaries of Percent Time In Operating Mode: Offensive Scenario By levels of Operating Mode and Duty Position

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		25.0000	42.9238	136
Manual Search		38.2938	23.9301	34
Autoscan		33.4179	25.7931	34
GLOS		25.8191	22.6507	34
GPS		2.4693	3.3855	34

*** CELL MEANS ***

	Co Cdr	Plt Ldr	TC
Manual Search	51.53 (5)	36.30 (15)	35.70 (14)
Autoscan	7.00 (5)	40.49 (15)	35.28 (14)
GLOS	38.34 (5)	21.51 (15)	25.97 (14)
GPS	3.13 (5)	1.70 (15)	3.06 (14)

*** ANALYSIS OF VARIANCE ***

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	25700.293	5	5140.059	12.313	.000
MODE	25700.293	3	8566.764	20.522	.000
POSITION	.000	2	.000	.000	1.000
2-way Interactions	6397.879	6	1066.313	2.554	.023
MODE POSITION	6397.879	6	1066.313	2.554	.023
Explained	32098.171	11	2918.016	6.990	.000
Residual	51763.030	124	417.444		
Total	83861.201	135	621.194		

Summaries of **Percent Time in Operating Mode**: Defensive Scenario By levels of Operating Mode and Duty Position

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		25.0000	23.4421	140
Manual Search		31.4992	21.9432	35
Autoscan		38.3467	22.4684	35
GLOS		26.6315	23.1664	35
GPS		3.5226	4.3773	35

*** CELL MEANS ***

	Co Cdr	Plt Ldr	TC
Manual Search	33.94 (5)	32.69 (15)	29.50 (15)
Autoscan	16.33 (5)	40.37 (15)	43.66 (15)
GLOS	46.26 (5)	24.04 (15)	22.68 (15)
GPS	3.47 (5)	2.90 (15)	4.16 (15)

*** ANALYSIS OF VARIANCE ***

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	23951.060	5	4790.212	13.007	.000
MODE	23951.060	3	7983.687	21.678	.000
POSITION	.000	2	.000	.000	1.000
2-way Interactions	5294.043	6	882.341	2.396	.032
MODE/ POSITION	5294.043	6	882.341	2.396	.032
Explained	29245.103	11	2658.646	7.219	.000
Residual	47139.886	128	368.280		
Total	76384.989	139	549.532		

Summaries of Percent Time In Magnification Mode: Offensive Scenario
By levels of Magnification and Position

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		50.0000	32.0234	68
3X		50.8867	32.2525	34
10X		49.1133	32.2525	34

*** CELL MEANS ***

	Co Cdr	Plt Ldr	TC
3X	43.56 (5)	49.37 (15)	55.12 (14)
10X	56.44 (5)	50.63 (15)	44.88 (14)

*** ANALYSIS OF VARIANCE ***

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	53.460	3	17.820	.016	.997
MAGNIFICATION	53.460	1	53.460	.049	.825
POSITION	.000	2	.000	.000	1.000
2-way Interactions	1107.935	2	553.967	.508	.604
MAGNIFICATION/ POSITION	1107.935	2	553.967	.508	.604
Explained	1161.395	5	232.279	.213	.956
Residual	67546.875	62	1089.466		
Total	68708.270	67	1025.497		

Summaries of **Percent Time in Magnification Mode**: Defensive Scenario
By levels of Magnification and Position

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		50.0000	29.1919	70
3X		45.9514	29.1175	35
10X		54.0486	29.1175	35

*** CELL MEANS ***

	Co Cdr	Plt Ldr	TC
3X	36.71 (5)	40.77 (15)	54.22 (15)
10X	63.29 (5)	59.23 (15)	45.78 (15)

*** ANALYSIS OF VARIANCE ***

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	1147.390	3	382.463	.454	.716
MAGNIFICATION	1147.390	1	1147.390	1.361	.248
POSITION	.000	2	.000	.000	1.000
2-way Interactions	3708.868	2	1854.434	2.200	.119
MAGNIFICATION/ POSITION	3708.868	2	1854.434	2.200	.119
Explained	4856.257	5	971.251	1.152	.342
Residual	53943.416	64	842.866		
Total	58799.673	69	852.169		

Summaries of Number of Times AutoScan Sectors Set: Offensive Scenario
By levels of Duty Position

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1.00	Co Cdr	1.5411	.1934	.1497	5
2.00	Plt Ldr	3.8903	1.5606	34.0946	15
3.00	TC	4.1517	2.8755	115.7596	15
Within Groups Total		3.6667	2.1651	150.0039	35

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	26.8693	2	13.4347	2.8660	.0716
Within Groups	150.0039	32	4.6876		

Eta = .3898 Eta Squared = .1519

Appendix C

Rating Distributions for Soldier-Completed Instruments

Appendix C specifically includes the following:

C-A	CCD Evaluation Items
C-B	CITV Evaluation Items
C-C	Gunner's Evaluation Items
C-D	Driver's Evaluation Items

Appendix C-A

CCD Evaluation Items

Rating Distributions by Duty Position
CCD Evaluation Items

It was easy to scroll the Tactical Map.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	4	-	1	-
Pl Ldr N=15	3	5	4	3	-
TC N=15	1	7	4	2	1
All N=35	4	16	8	6	1

Mean = 2.54 Std Dev = 1.01

The touch screen made it easy to operate the CCD.

Co Cdr N=5	-	2	2	1	-
Pl Ldr N=14	6	3	2	2	1
TC N=15	3	8	3	-	1
All N=34	9	13	7	3	2

Mean = 2.29 Std Dev = 1.14

The touch method was an accurate method of operating the display.

Co Cdr N=5	-	-	3	2	-
Pl Ldr N=14	6	2	3	2	1
TC N=15	4	7	2	1	1
All N=34	10	9	8	5	2

Mean = 2.41 Std Dev = 1.23

Rating Distributions by Duty Position
CCD Evaluation Items

The thumb control was easy to use.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	3	-	1	1
Pl Ldr N=15	-	1	2	4	8
TC N=15	1	-	1	8	5
All N=35	1	4	3	13	14

Mean = 4.00 Std Dev = 1.11

It was difficult to operate the thumb control because the front finger switches were in the way.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	1	1	3	-
Pl Ldr N=15	2	1	5	5	2
TC N=15	1	3	7	3	1
All N=35	3	5	13	11	3

Mean = 3.17 Std Dev = 1.07

It was easy to change the waypoints.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	4	1	-	-
Pl Ldr N=15	5	9	-	-	1
TC N=15	5	7	1	2	-
All N=35	10	20	2	2	1

Mean = 1.97 Std Dev = .92

Rating Distributions by Duty Position
CCD Evaluation Items

Having different tank icons on the CITV and the CCD was confusing.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	-	4	1
Pl Ldr N=15	-	-	3	9	3
TC N=15	-	3	3	7	2
All N=35	-	3	6	20	6

Mean = 3.83 Std Dev = .82

It was easy to create reports on the CCD.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	2	3	-
Pl Ldr N=15	-	4	2	6	3
TC N=15	-	8	4	2	1
All N=35	-	12	8	11	4

Mean = 3.20 Std Dev = 1.05

It was difficult to manage all of the reports sent to me over the CCD.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	2	1	2	-	-
Pl Ldr N=15	6	6	2	1	-
TC N=15	2	3	4	6	-
All N=35	10	10	8	7	-

Mean = 2.34 Std Dev = 1.11

Rating Distributions by Duty Position
CCD Evaluation Items

I spent too much time getting CFF and Adjust Fire messages out with the CCD system.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	2	1	-	2	-
Pl Ldr N=15	1	5	4	4	1
TC N=15	2	6	5	2	-
All N=35	5	12	9	8	1

Mean = 2.66 Std Dev = 1.08

It took me longer to create and send a SPOT report with the CCD than it would have taken me to send it over the radio.

Co Cdr N=5	-	2	3	-	-
Pl Ldr N=15	5	4	2	3	1
TC N=15	6	6	1	2	-
All N=35	11	12	6	5	1

Mean = 2.23 Std Dev = 1.14

I did not need to know the type and number of messages sent to me.

Co Cdr N=5	-	-	1	2	2
Pl Ldr N=15	-	1	7	5	2
TC N=15	-	2	2	10	1
All N=35	-	3	10	17	5

Mean = 3.69 Std Dev = .83

Rating Distributions by Duty Position
CCD Evaluation Items

There is enough space in the Menu Window to make choices and prepare reports using the touch method.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	1	2	1	1
Pl Ldr N=15	1	4	4	4	2
TC N=15	-	8	5	1	1
All N=35	1	13	11	6	4

Mean = 2.97 Std Dev = 1.07

It was easy to read the information presented in the Information Center (ie. DTG, Heading, Alert Status).

Co Cdr N=5	3	2	-	-	-
Pl Ldr N=15	7	7	1	-	-
TC N=15	6	8	1	-	-
All N=35	16	17	2	-	-

Mean = 1.60 Std Dev = .60

I had trouble understanding the abbreviations used in the menu area.

Co Cdr N=5	-	-	-	3	2
Pl Ldr N=15	1	-	-	12	2
TC N=15	1	3	3	7	1
All N=35	2	3	3	22	5

Mean = 3.71 Std Dev = 1.02

Rating Distributions by Duty Position
CCD Evaluation Items

I found it easy to move from one menu to the next.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	1	1	2	1
Pl Ldr N=15	2	6	3	4	-
TC N=15	1	7	3	3	1
All N=35	3	14	7	9	2

Mean = 2.80 Std Dev = 1.11

I found having several highlighted fields at one time in the reports to be confusing.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	1	1	3	-
Pl Ldr N=15	-	3	3	6	3
TC N=15	1	3	2	7	2
All N=35	1	7	6	16	5

Mean = 3.49 Std Dev = 1.07

The commander's override control contains too many functions.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	2	1	2	-
Pl Ldr N=15	2	-	5	6	2
TC N=15	-	1	3	8	3
All N=35	2	3	9	16	5

Mean = 3.54 Std Dev = 1.04

Rating Distributions by Duty Position
CCD Evaluation Items

I trusted the information presented to me on the CCD.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	5	-	-	-
Pl Ldr N=15	3	9	2	-	1
TC N=15	5	8	2	-	-
All N=35	8	22	4	-	1

Mean = 1.97 Std Dev = .79

Using the CCD did not strain my eyes.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	4	1	-	-
Pl Ldr N=15	1	6	5	3	-
TC N=15	1	8	2	3	1
All N=35	2	18	8	6	1

Mean = 2.60 Std Dev = .95

The Tactical Map would not be useful without the added Report Menu functions.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	3	1	1	-
Pl Ldr N=15	-	2	-	7	6
TC N=15	-	4	2	6	3
All N=35	-	9	3	14	9

Mean = 3.66 Std Dev = 1.14

Rating Distributions by Duty Position
CCD Evaluation Items

The Tactical Map is too small.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	-	3	2
Pl Ldr N=15	2	1	2	8	2
TC N=15	-	2	4	8	1
All N=35	2	3	6	19	5

Mean = 1.74 Std Dev = .85

The CCD display often presented too much information.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	1	1	1	1
Pl Ldr N=15	3	6	-	6	-
TC N=15	-	3	5	6	1
All N=35	4	10	6	13	2

Mean = 2.97 Std Dev = 1.18

Map icons and symbols were easy to understand.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	2	1	1	-
Pl Ldr N=15	0	9	3	1	2
TC N=15	2	5	4	4	-
All N=35	3	16	8	6	2

Mean = 2.66 Std Dev = 1.06

Rating Distributions by Duty Position
CCD Evaluation Items

The Tactical Map with POSNAV is more helpful for navigating than a paper map.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	3	2	-	-	-
Pl Ldr N=15	12	2	1	-	-
TC N=15	6	8	1	-	-
All N=35	21	12	2	-	-

Mean = 1.46 Std Dev = .61

Using overlays on the Tactical Map was easier than using grease pencils and lap maps.

Co Cdr N=5	3	2	-	-	-
Pl Ldr N=15	11	4	-	-	-
TC N=15	10	5	-	-	-
All N=35	24	11	-	-	-

Mean = 1.31 Std Dev = .47

The terrain features were distracting.

Co Cdr N=5	-	-	2	1	2
Pl Ldr N=15	-	-	2	11	2
TC N=15	-	-	3	9	3
All N=35	-	-	7	21	7

Mean = 4.0 Std Dev = .64

Rating Distributions by Duty Position
CCD Evaluation Items

By sending waypoints, I was able to give the driver more responsibility.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	2	3	-	-	-
Pl Ldr N=15	9	6	-	-	-
TC N=15	9	5	1	-	-
All N=35	20	14	1	-	-

Mean = 1.46 Std Dev = .56

I needed to input more than 6 waypoints at a time.

Co Cdr N=5	1	1	1	2	-
Pl Ldr N=15	-	3	3	8	1
TC N=15	1	-	4	8	2
All N=35	2	4	8	18	3

Mean = 3.46 Std Dev = 1.01

The reports I received over CCD still contained valuable information by the time I read them.

Co Cdr N=5	-	2	3	-	-
Pl Ldr N=15	3	5	6	1	-
TC N=15	-	11	4	1	1
All N=35	3	18	16	1	-

Mean = 2.34 Std Dev = 1.06

Rating Distributions by Duty Position
CCD Evaluation Items

I had enough time to read all of my messages.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	-	3	2
Pl Ldr N=15	-	3	-	8	4
TC N=15	-	4	3	5	3
All N=35	-	7	3	16	9

Mean = 3.77 Std Dev = 1.06

It was useful to have automated prompts (highlighted areas) in the reports.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	5	-	-	-
Pl Ldr N=15	5	8	1	-	1
TC N=15	5	8	1	1	-
All N=35	10	21	2	1	1

Mean = 1.91 Std Dev = .85

The tank icon on the CCD helped me keep track of my direction.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	4	-	-	1	-
Pl Ldr N=15	6	8	-	-	1
TC N=15	9	6	-	-	-
All N=35	19	14	-	1	1

Mean = 1.60 Std Dev = .88

Rating Distributions by Duty Position
CCD Evaluation Items

The technical difficulties I experienced with my CCD (if any) did not interfere with my ability to command my tank.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	1	2	-	1
Pl Ldr N=15	2	2	1	7	3
TC N=15	4	4	4	2	1
All N=35	7	7	7	9	5

Mean = 2.94 Std Dev = 1.37

I feel the CCD would improve my "real world" performance as a tank commander.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	2	2	1	-	-
Pl Ldr N=15	9	5	1	-	-
TC N=15	6	4	4	1	-
All N=35	17	11	6	1	

Mean = 1.74 Std Dev = .85

When entering route waypoints, I prefer to enter grid coordinates with the thumb control rather than touching the map.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	2	-	1	-	2
Pl Ldr N=15	1	1	-	6	7
TC N=15	1	2	-	5	7
All N=35	4	3	1	11	16

Mean = 3.91 Std Dev = 1.38

Rating Distributions by Duty Position
CCD Evaluation Items

I frequently changed the scale of the Tactical Map.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	4	-	-	-
Pl Ldr N=15	5	7	1	2	-
TC N=15	3	7	1	3	1
All N=35	9	18	2	5	1

Mean = 2.17 Std Dev = 1.07

I usually touched the map, instead of lasing to the target, when entering grid coordinates into reports.

Co Cdr N=5	2	1	1	1	-
Pl Ldr N=15	3	-	1	9	2
TC N=15	3	2	2	6	2
All N=35	8	3	4	16	4

Mean = 3.14 Std Dev = 1.40

I frequently posted symbols to my Tactical Map.

Co Cdr N=5	-	3	1	1	-
Pl Ldr N=15	1	8	3	3	-
TC N=15	-	6	7	1	1
All N=35	1	17	11	5	1

Mean = 2.66 Std Dev = .87

Rating Distributions by Duty Position
CCD Evaluation Items

I used CCD information when assigning CITV sectors.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	2	3	-
Pl Ldr N=15	1	6	6	2	-
TC N=14	2	8	-	3	1
All N=34	3	14	8	1	1

Mean = 2.71 Std Dev = 1.03

I spent more time looking at CITV than I did looking at the CCD.

Co Cdr N=5	-	-	1	2	2
Pl Ldr N=15	-	4	6	5	-
TC N=15	1	7	5	2	-
All N=35	1	11	12	9	2

Mean = 3.00 Std Dev = .97

I spent more time looking at the CCD system than I did looking through the vision blocks and sights.

Co Cdr N=5	4	1	-	-	-
Pl Ldr N=15	7	5	1	1	1
TC N=15	2	6	3	3	1
All N=35	13	12	4	4	2

Mean = 2.14 Std Dev = 1.22

Rating Distributions by Duty Position
CCD Evaluation Items

I spent less time looking at the CCD than I tactically should have.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	-	1	3	-
Pl Ldr N=15	-	1	2	9	3
TC N=15	-	2	4	7	2
All N=35	1	3	7	19	5

Mean = 3.69 Std Dev = .93

Appendix C-B

CITV Evaluation Items

Rating Distributions by Duty Position
CITV Evaluation Items

The CITV display functions were difficult to use while on the move.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	2	2	1
Pl Ldr N=15	-	2	2	8	3
TC N=15	2	2	6	5	-
All N=35	2	4	10	15	4

Mean = 3.43 Std Dev = 1.04

Using the CITV for several hours made my eyes tired or achy.

Co Cdr N=5	-	-	3	2	-
Pl Ldr N=15	1	5	4	5	-
TC N=15	1	4	4	6	-
All N=35	2	9	11	13	-

Mean = 3.00 Std Dev = .94

I sometimes forgot to switch over to the GPSE Mode to activate the commander's override.

Co Cdr N=5	-	4	1	-	-
Pl Ldr N=14	1	5	2	4	2
TC N=15	4	7	2	1	1
All N=34	5	16	5	5	3

Mean = 2.56 Std Dev = 1.19

Rating Distributions by Duty Position
CITV Evaluation Items

The SIMNET CITV thermal signatures provide greater detail than is provided by the thermal systems in tanks.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	2	2	-	-
Pl Ldr N=15	2	6	2	3	2
TC N=15	4	4	4	2	1
All N=35	7	12	8	5	3

Mean = 2.57 Std Dev = 1.22

It was easy to hand-off targets to the Gunner using the Target-stacking function.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	-	2	-	2
Pl Ldr N=15	1	2	3	3	6
TC N=15	3	2	5	-	5
All N=35	5	4	10	3	13

Mean = 3.43 Std Dev = 1.46

It was difficult to change the rate of the AutoScan.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	1	3	1
Pl Ldr N=15	-	-	1	5	9
TC N=15	-	-	-	7	8
All N=35	-	-	2	15	18

Mean = 4.46 Std Dev = .61

Rating Distributions by Duty Position
CITV Evaluation Items

The Manual Search mode was easy to use.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	3	2	-	-	-
Pl Ldr N=15	7	8	-	-	-
TC N=15	7	7	-	1	-
All N=35	17	17	-	1	-

Mean = 1.57 Std Dev = .65

The IFF function was difficult to use.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	1	1	1	1
Pl Ldr N=15	-	-	2	10	3
TC N=15	1	-	5	6	3
All N=35	2	1	8	17	7

Mean = 3.74 Std Dev = 1.01

The CITV screen is too small.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	-	3	2
Pl Ldr N=15	-	-	2	9	4
TC N=15	-	2	3	8	2
All N=35	-	2	5	20	8

Mean = 3.97 Std Dev = .79

Rating Distributions by Duty Position
CITV Evaluation Items

The CITV tank icon was useful for orienting my tank in the proper direction.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	3	-	2	-	-
Pl Ldr N=15	7	5	-	1	2
TC N=15	4	6	3	1	1
All N=35	14	11	5	2	3

Mean = 2.11 Std Dev = 1.25

There was too much information on the CITV display screen.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	1	3	1
Pl Ldr N=15	-	2	1	10	2
TC N=15	-	2	2	9	2
All N=35	-	2	4	22	5

Mean = 3.80 Std Dev = .83

The CITV allowed me to give the gunner more responsibility over the target kill assessment.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	3	2	-	-
Pl Ldr N=15	4	10	1	-	-
TC N=15	6	8	1	-	-
All N=35	10	21	4	-	-

Mean = 1.83 Std Dev = .62

Rating Distributions by Duty Position
CITV Evaluation Items

The CITV enabled me to acquire targets at greater ranges.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	2	2	1	-
Pl Ldr N=15	5	6	3	-	1
TC N=15	5	7	3	-	-
All N=35	10	15	8	1	1

Mean = 2.09 Std Dev = .95

The CITV enabled me to acquire targets more quickly.

Co Cdr N=5	3	-	1	1	-
Pl Ldr N=15	6	9	-	-	-
TC N=15	8	6	1	-	-
All N=35	17	15	2	1	-

Mean = 1.63 Std Dev = .73

The CITV was useful in controlling fire distribution to prevent target overkill and ammo expenditure.

Co Cdr N=5	-	1	4	-	-
Pl Ldr N=15	1	7	5	2	-
TC N=15	3	5	6	1	-
All N=35	4	13	15	3	-

Mean = 2.49 Std Dev = .82

Rating Distributions by Duty Position
CITV Evaluation Items

With the CITV I could orient my tank to cover my assigned sectors more rapidly than I could without it.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	3	2	-	-
Pl Ldr N=15	4	7	2	2	-
TC N=15	3	8	2	2	-
All N=35	7	18	6	4	-

Mean = 2.20 Std Dev = .90

The CITV helped me to identify key terrain features important for command and control.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	2	1	-	1	1
Pl Ldr N=15	-	2	8	5	-
TC N=15	1	5	4	5	-
All N=35	3	8	12	11	1

Mean = 2.97 Std Dev = 1.01

As the number of targets presented increased, the usefulness of the CITV increased.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	2	2	-	-
Pl Ldr N=15	5	9	1	-	-
TC N=15	3	10	1	1	-
All N=35	9	21	4	1	-

Mean = 1.91 Std Dev = .70

Rating Distributions by Duty Position
CITV Evaluation Items

The technical difficulties I experienced with my CITV (if any) did not interfere with my ability to command my tank.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	1	-	1	3	-
Pl Ldr N=14	2	5	6	1	-
TC N=15	1	5	6	1	2
All N=34	4	10	13	5	2

Mean = 2.74 Std Dev = 1.05

I feel the CITV would improve my "real world" performance as a tank commander.

Co Cdr N=5	3	1	1	-	-
Pl Ldr N=15	8	7	-	-	-
TC N=15	5	6	3	1	-
All N=35	16	14	4	1	-

Mean = 1.71 Std Dev = .79

While my gunner was engaging a target I used the CITV to search for more targets.

Co Cdr N=5	-	2	2	1	-
Pl Ldr N=15	6	9	-	-	-
TC N=15	11	3	-	-	1
All N=35	17	14	2	1	1

Mean = 1.71 Std Dev = .93

Rating Distributions by Duty Position
CITV Evaluation Items

I used the CITV more often than I did the vision blocks and GPSE.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	2	3	-	-	-
Pl Ldr N=15	10	3	1	1	-
TC N=15	5	6	3	1	-
All N=35	17	12	4	2	-

Mean = 1.74 Std Dev = .89

The CITV was more helpful in defensive than in offensive operations.

Co Cdr N=5	1	1	3	-	-
Pl Ldr N=15	3	2	4	4	2
TC N=15	4	1	7	3	-
All N=35	8	4	14	7	2

Mean = 2.74 Std Dev = .88

The CITV was more helpful in offensive than in defensive operations.

Co Cdr N=5	-	-	3	1	1
Pl Ldr N=15	1	1	4	6	3
TC N=15	-	1	11	3	-
All N=35	1	2	18	10	4

Mean = 3.40 Std Dev = .88

Rating Distributions by Duty Position
CITV Evaluation Items

I used the CITV to maintain unit command and control.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	2	1	-	1	1
Pl Ldr N=15	4	7	2	2	-
TC N=14	1	2	7	4	-
All N=34	7	10	9	7	1

Mean = 2.49 Std Dev = 1.20

I rarely used the Manual Search mode.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	2	1	2
Pl Ldr N=15	-	1	-	5	9
TC N=15	-	-	6	7	2
All N=35	-	1	8	13	13

Mean = 4.09 Std Dev = .85

I rarely used the Target-stacking function to designate targets to the Gunner.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	3	1	1	-	-
Pl Ldr N=15	9	2	4	-	-
TC N=15	6	6	1	-	2
All N=35	18	9	6	-	2

Mean = 1.83 Std Dev = 1.10

Rating Distributions by Duty Position
CITV Evaluation Items

I prefer to use AutoScan in offensive operations more than in defensive operations.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	1	2	2
Pl Ldr N=15	-	1	5	6	3
TC N=15	3	1	6	4	1
All N=35	3	2	12	12	6

Mean = 3.46 Std Dev = 1.12

I prefer to use AutoScan in defensive operations more than in offensive operations.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	2	2	-	-	1
Pl Ldr N=15	2	7	4	1	1
TC N=15	4	2	6	2	1
All N=35	8	11	10	3	3

Mean = 2.49 Std Dev = 1.20

I prefer to use the Target-stacking function in offensive operations more than defensive operations.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	-	2	2	1
Pl Ldr N=15	-	-	2	3	9
TC N=14	-	1	5	4	5
All N=34	-	1	9	9	15

Mean = 4.12 Std Dev = .91

Rating Distributions by Duty Position
CITV Evaluation Items

I prefer to use the Target-stacking function in defensive operations more than offensive operations.

Position	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Co Cdr N=5	-	2	2	-	1
Pl Ldr N=15	1	6	3	-	5
TC N=15	1	3	4	3	4
All N=35	2	11	9	3	10

Mean = 3.23 Std Dev = 1.33

Appendix C-C

Gunner's Evaluation Items

Gunner's Evaluation Items

Item	N	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Std Dev
The thermal signatures in SIMNET are not accurate.	N=34	3	10	7	10	3	3.00	1.17
I liked having my TC designate me on to new targets.	N=34	11	9	6	6	1	2.30	1.21
I found it easy to get disoriented when my TC designated me to a target.	N=34	4	7	6	10	6	3.21	1.32
The fire commands I use in a real tank were not adequate in the simulator when my TC designated targets.	N=34	5	4	9	12	3	3.12	1.22
The fire commands I use in a real tank were not adequate in the simulator when using Target Stacking.	N=34	4	8	10	8	3	2.94	1.17
I engaged targets more often in the thermal mode.	N=34	18	3	6	5	1	2.03	1.29
The Target Stacking function was easy to use.	N=34	2	2	18	6	5	3.30	1.02
When using the target stacking function, I would prefer to designate myself to new targets.	N=34	9	6	11	6	1	2.52	1.18

Gunner's Evaluation Items

As the number of targets presented increased, the usefulness of target designate increased.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=34	8	6	10	9	-

Mean = 2.61 Std Dev = 1.14

I used the lights on the Target Stack panel to determine which direction the turret would move.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=34	1	6	13	8	5

Mean = 3.30 Std Dev = 1.05

I would prefer that the information from the target stack panel lights be presented in the GPS.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=34	2	8	9	8	6

Mean = 2.79 Std Dev = 1.22

I never need to have 4 targets stacked at any one time.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=34	5	12	11	4	1

Mean = 2.52 Std Dev = 1.00

I would prefer to have the stacked targets automatically prioritized.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=34	6	6	14	3	4

Mean = 2.79 Std Dev = 1.22

Target hand-offs were smooth and allowed me to acquire targets more quickly.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=34	6	12	11	3	1

Mean = 2.42 Std Dev = 1.00

I would prefer the TC make the kill assessment rather than making the gunner responsible for it.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=34	1	4	5	15	8

Mean = 3.76 Std Dev = 1.06

In a real tank, I feel the Target Stack and Designate equipment would enable me to destroy more targets.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=34	7	11	7	5	3

Mean = 2.58 Std Dev = 1.25

Appendix C-D

Driver's Evaluation Items

Driver's Evaluation Items

The Driver's Display was difficult to use.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=35	-	1	1	10	23

Mean = 4.57 Std Dev = .70

I had no trouble receiving waypoints on the Driver's Display from my TC.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=35	12	13	3	6	1

Mean = 2.17 Std Dev = 1.18

Fewer communications were needed with the TC because of the Steer-To indicator.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=35	19	14	1	-	1

Mean = 1.57 Std Dev = .81

I would prefer waypoints to be sent automatically.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=34	14	11	8	1	-

Mean = 1.88 Std Dev = .88

In a real tank, I could use terrain features more easily and could maneuver better if I had the Steer-To indicator.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=35	15	8	8	3	1

Mean = 2.06 Std Dev = 1.14

The Steer-To indicator responds too slowly.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=35	2	4	11	12	6

Mean = 3.46 Std Dev = 1.09

I think drivers would become too dependent on the Steer-To display if it were put into a real tank.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=35	3	6	15	7	4

Mean = 3.08 Std Dev = 1.09

My TC sometimes forgot to send me new waypoints.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=35	2	11	3	11	8

Mean = 3.34 Std Dev = 1.30

I would prefer to see all the waypoints at once instead of seeing them one at a time.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
N=35	3	7	8	10	7

Mean = 3.31 Std Dev = 1.25

Driver's Evaluation Items

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Having a Steer-To indicator gave me more confidence in moving from point to point.					
N=35	16	12	3	3	1
Mean = 1.88			Std Dev = 1.08		
In a real tank, I feel the Steer-To indicator would improve my performance as a Driver.					
N=35	14	12	8	-	1
Mean = 1.91			Std Dev = .95		

Appendix D

Descriptive Statistics for Automated Measures

Appendix D specifically includes the following:

Average Percent Time per Phase in each Map Scale
Average Percent Time per Phase in each Operating Mode

Average Percent Time per Phase in each Map Scale, Offensive (Off) and Defensive (Def) Scenarios: Means and Standard Deviations (in parenthesis)

Position	**1:25,000**		**1:50,000**		**1:125,000**		**1:250,000**	
	Off	Def	Off	Def	Off	Def	Off	Def
Co Cdr N=4	3.53 (6.84)	.71 (.83)	77.51 (19.46)	80.68 (15.34)	18.34 (13.32)	16.31 (16.70)	.63 (1.26)	2.30 (2.88)
Plt Ldr N=12	14.26 (23.24)	20.09 (19.87)	71.72 (21.67)	71.65 (20.15)	12.00 (12.83)	7.45 (8.13)	2.02 (3.16)	.81 (1.20)
TC N=12	25.50 (37.51)	32.66 (34.33)	62.15 (41.94)	51.88 (39.71)	11.13 (28.31)	14.67 (29.94)	1.22 (2.27)	.80 (.99)

Average Percent Time per Phase in each Operating Mode, Offensive (Off) and Defensive (Def) Scenarios: Means and Standard Deviations (in parenthesis)

Position	Manual Search		Auto Scan		GLOS		GPS	
	Off	Def	Off	Def	Off	Def	Off	Def
Co Cdr N=5	51.53 (28.11)	33.94 (31.73)	7.00 (9.70)	16.33 (16.72)	38.34 (25.87)	46.26 (33.84)	3.13 (5.12)	3.47 (5.95)
Plt Ldr N=15	36.30 (23.77)	32.69 (18.15)	40.49 (26.38)	40.37 (22.59)	21.51 (19.22)	24.04 (19.35)	1.70 (2.60)	2.90 (4.10)
TC N=14	35.70 (22.85)	29.50 (23.33)	35.28 (24.09)	43.66 (20.69)	25.87 (24.94)	22.68 (20.98)	3.06 (3.54)	4.16 (4.33)

Appendix E

CCD Report Formats

CCD Report Formats

1. <u>CONTACT REPORT</u>
   Purpose: Report Initial Contact With Enemy Forces
   Format:

   LINE #1: WHAT (Tank, PC, Arty, Truck, Helo)
   LINE #2: WHERE (Grid Coordinates)

2. <u>CALL FOR FIRE (CFF) REPORT</u>
   Purpose: Request Indirect Fire
   Format:

   LINE #1: WHAT (Tank, PC, Truck, Arty, Helo)
   LINE #2: WHERE (Grid Coordinates)
   LINE #3: TYPE FIRE (Immediate Suppression, Fire For Effect)

3. <u>ADJUST FIRE REPORT</u>
   Purpose: Adjust Indirect Artillery Or Mortar Fires
   Format:

   LINE #1: ADJUST - LEFT/RIGHT (50, 100, 200, 500 meters)
   LINE #2: ADJUST - ADD/DROP (50, 100, 200, 500 meters)
   LINE #3: TYPE FIRE (Fire for Effect, End of Mission)

4. <u>SPOT REPORT</u>
   Purpose: Report Results of Enemy Contacts, Enemy Activities, And Friendly Activities
   Format:

   PAGE 1: Results of Enemy Contacts
   LINE #1: WHAT (Tank, PC, Truck, Arty, Helo)
   LINE #2: NUMBER DAMAGED
   LINE #3: NUMBER DESTROYED
   LINE #4: WHERE (Grid Coordinates)
   LINE #5: HEADING (Degrees)

   PAGE 2: Enemy/Friendly Activity
   LINE #1: ENEMY ACTIVITY (Moving, Defending, Attacking, Observing)
   LINE #2: FRIENDLY ACTIVITY (Moving, Defending, Attacking, Observing)
   LINE #3: AS OF TIME (Now, -5, -10, -15, -30, -45 Minutes)

5. <u>SHELL REPORT</u>
   Purpose: Report Enemy Indirect Fire Activities and Locations
   Format:

   LINE #1: NUMBER OF SHELLS/ROUNDS
   LINE #2: WHERE (Grid Coordinates)
   LINE #3: AS OF TIME (Now, -5, -10, -15, -30, -45 Minutes)

6. SITUATION REPORT

Purpose: Report the Commanders/Leaders Location, Enemy Activity, Critical Shortages, and Intent

Format:

PAGE 1: Location/Enemy Activity
LINE #1: AS OF TIME (Now, -5, -10, -15, -30, -45 Minutes)
LINE #2: FORWARD LINE OF OWN TROOPS (Grid Coordinates, From-To)
LINE #3: ENEMY ACTIVITY (Light, Medium, Heavy)
LINE #4: TYPE OF ACTIVITY (Ground Attack, Air Attack, Fire, Defend, Delay, Withdraw)

PAGE 2: Shortages/Intent
LINE #5: CRITICAL SHORTAGES (Personnel, Ammo, Equipment, Fuel)
LINE #6: COMMANDER'S INTENT (No Change, Attack, Recon, Defend, Delay, Withdraw)

7. AMMUNITION REPORT

Purpose: Report Status of Ammunition for Weapon System

Format:

LINE #1:	HEAT:	STATUS (Green, Amber, Red, Black)
LINE #2:	SABOT:	STATUS (Green, Amber, Red, Black)
LINE #3:	.50 cal:	STATUS (Green, Amber, Red, Black)
LINE #4:	7.62mm:	STATUS (Green, Amber, Red, Black)
LINE #5:	SMOKE:	STATUS (Green, Amber, Red, Black)

8. INTELLIGENCE REPORT

Purpose: Report Enemy Activities, Friendly Activities, Obstacle Locations

Format:

PAGE 1: Enemy Activities
LINE #1: WHAT (Tank, PC, Truck, Arty, Helo)
LINE #2: NUMBER (1, 5, 7, 10, 25, etc.)
LINE #3: ACTIVITY (Ground Attack, Air Attack, Fire, Defend, Delay, Withdraw)
LINE #4: WHERE (Grid Coordinates)
LINE #5: HEADING (Degrees)

PAGE 2: Friendly Activities
LINE #6: WHAT (Tank, PC, Truck, Arty, Helo)
LINE #7: NUMBER (1, 5, 7, 10, 25, etc.)
LINE #8: ACTIVITY (Ground Attack, Air Attack, Fire, Defend, Delay, Withdraw)
LINE #9: WHERE (Grid Coordinates)
LINE #10: HEADING (Degrees)

PAGE 3: Obstacles
LINE #11: WHAT (Minefield, Abatis, Wire Obstacle, Blown Bridges)
LINE #12: AS OF TIME (Now, -5, -10, -15, -30, -45)

9. NBC REPORT
Purpose: Report Enemy Nuclear, Biological, and Chemical Operations, Activities, or Attacks
Format:

PAGE 1: Location/Type Burst/Type Attack
LINE #1: OBSERVER LOCATION (Grid Coordinates)
LINE #2: ATTACK LOCATION (Grid Coordinates)
LINE #3: TYPE OF BURST (Air or Surface)
LINE #4: TYPE OF ATTACK (Nuclear, Chemical, Biological)

PAGE 2: Nuclear Attack Information
LINE #5: FLASH/BANG TIME (In Seconds)
LINE #6: NUMBER OF SHELLS/ROUNDS (1, 5, 10, 25, etc.)
LINE #7: NUCLEAR CENTER DIAMETER (In Meters)
LINE #8: NUCLEAR CLOUD WIDTH (In Degrees)
LINE #9: NUCLEAR CLOUD HEIGHT (In Degrees)

Appendix F

Acronym List

CVCC EVALUATION
ACRONYM LIST

ACRONYM	DEFINITION
ANOVA	Analysis of Variance
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ARTEP	Army Training and Evaluation Program
BBN	Bolt, Beranek & Newman Systems Inc.
BDM	BDM International, Inc.
BHOT	Black Hot
BMS	Battlefield Management System
BOS	Battlefield Operating System
BP	Battle Position
C2	Command and Control
C3	Command, Control and Communication
Co CDR	Company Commander
CCD	Command and Control Display
CCTB	Close Combat Test Bed
CFF	Call for Fire
CITV	Commander's Independent Thermal Viewer
CRT	Cathode Ray Tube
CVCC	Combat Vehicle Command and Control
DCA	Data Collection & Analysis System
DCD	Directorate of Combat Developments
df	Degrees of Freedom
DTG	Date-Time-Group
ECR	Exercise Control Room
FRAGO	Fragmentary Order
GLOS	Gun Line of Sight
GPS	Gunner's Primary Sight
GPSE	Gunner's Primary Sight Extension
IRIS	Integrated Roster Imaging System
IVIS	Intervehicular Information System
LOS	Line of Sight
LRF	Laser Range Finder
MANOVA	Multivariate Analysis of Variance
MCC	Management, Command and Control System
MOS	Military Occupational Specialty
NBC	Nuclear, Biological, Chemical
NCO	Non-Commissioned Officer
OPFOR	Opposing Forces
Plt Ldr	Platoon Leader
POSNAV	Position Navigation
Plt Sgt	Platoon Sergeant
PVD	Plan View Display
PW	Platoon Leader's Wingman
R & D	Research and Development
RA	Research Assistant
SACCD	Stand-Alone CCD
SAFOR	Semiautomated Forces
SCC	SIMNET Control Console

SIM	Simulator
SIMNET	Simulation Network
SIMNET-D	Simulation Network--Developmental
SIMNET-T	Simulation Network--Training
SINCGARS	Single Channel Ground Airborne Radio System
SITREP	Situation Report
SME	Subject Matter Expert
SMI	Solder-Machine Interface
SOP	Standard Operating Procedure
SPSS	Statistical Package for the Social Sciences
SSI	Specialty Skill Identifier
TC	Tank Commander
TRP	Target Reference Point
UCOFT	Unit Conduct of Fire Trainer
UTM	Universal Transverse Mercator
WHOT	White Hot